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ABSTRACT

This volume of proceedings contains the keynote addresses, theme papers, and reports of the various technical sessions of the National Seminar on Educating the Engineers of the Future. A total of 10 technical sessions were held. Areas addressed included: (1) social and technological scenarios and technological forecasting; (2) technologies required; (3) new metallic elements for 2000 A.D.; (4) educational systems and technologies; (5) systems of education for 2000 A.D.; (6) education in basic sciences for 2000 A.D.; and (7) educating the engineer of the future in developing countries. Recommendations based on the conference are included in a final section. (Author/JN)

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NATIONAL SEMINAR
on
EDUCATING THE ENGINEER OF THE FUTURE

BANGALORE
JANUARY 7-10, 1979

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NATIONAL SEMINAR
ON
EDUCATING THE ENGINEER OF THE FUTURE
BANGALORE, JANUARY 7-10, 1979

Proceedings

The Institution of Engineers (India)
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NATIONAL SEMINAR ON EDUCATING THE ENGINEER OF THE FUTURE

The technical sessions of the National Seminar on 'Educating the Engineer of the Future' were held for three days during January 8-10 at Bangalore.

The first session which dealt with 'Social and Technological Scenarios and Technological Forecasting' was chaired by Lt-Gen J S Bawa. A key-note address by Sir Brian Flowers, FRS, Rector of Imperial College of Science and Technology, London, was the trend-setter; followed by another address entitled 'Socio-Economic Scenario of 2000 AD and a Techno-Feasible Strategy of Future' by Dr A Bhattacharyya.

Dr Jai Krishna chaired the second session. The theme papers presented were: (i) 'Social and Technological Scenarios' by Dr S C Seth, Department of Science and Technology, Government of India; (ii) 'Technological Forecasting the Technologies Required' by Shri F C Kohli, Director, Tata Consulting Services, Bombay.

The third session which dealt with the technologies required was chaired by Prof N S Govinda Rao. Dr H R Arikere, Vice-Chancellor, University of Agricultural Sciences, Bangalore, presented a key-note address on 'Technologies for Food'. This was followed by another address entitled 'Technologies for Energy in 2000 AD' by Shri S G Ramachandra, Senior Vice-President, Kirloskar Electric Co, Bangalore. Dr N S Ramaswamy, Director, IIM, Bangalore, also presented an interesting address on the utilization of animal power.

At the fourth session, chaired by Shri C S S Rao, Chairman, Indian Telephone Industries, Bangalore, two theme papers were presented: (i) 'New Metallic Materials for 2000 AD' by Dr E C Subba Rao, Professor of Metallurgical Engineering, IIT, Kanpur; and (ii) 'Novel Building Materials for 2000 AD' by Dr H C Visvesvaraya, Director General, Cement Research Institute of India, New Delhi.

A series of special lectures was also organized during the technical sessions. Guest speaker Prakash Tandon, Director General of National Council for Applied Economic Research, New Delhi, spoke on 'Some General Perspective in Management of Socio and Economic Parameters to 2000 AD'. Dr S M Patil, former Chairman of Hindustan Machine Tool Ltd, Bangalore, presided at this session.

Educational systems and technologies were discussed in the fifth session which was chaired by Shri J G Bodhe (F), Past President of the Institution. Dr Jagdish Narain (F), Vice-Chancellor of the University of Roorkee, presented his theme paper on 'Faculty Training for Education in 2000 AD' and Shri B G Shirke (F), Managing Director, Siporex India Ltd, Pune, spoke on 'Mass Housing'.

The sixth session was chaired by Dr S R Valluri, Director, National Aeronautical Laboratory, Bangalore. Two theme papers were presented at the session: (i) 'Non-formal System for 2000 AD' by Dr V C Kulandaiswamy (F), Vice-Chancellor, Madurai-Kamaraj University, Madurai; and (ii) 'Systems of Evaluation for 2000 AD' by Prof H N Ramachandra Rao (F), a former member of the Union Public Service Commission.

The seventh session served as a working group session and was devoted for presentation of papers. This National Seminar received a overwhelming response from members and others by way of technical contribution. Fifty-seven papers were classified and scheduled for presentation in three parallel groups. Group A which included papers dealing with technological forecasting and technologies required was chaired by Prof B R Narayana Iyenger (F), Principal (Retd), University Visvesvaraya College of Engineering, Bangalore. Following papers were scheduled for discussion in this group: (1) 'On Imparting Desired Knowledge in Engineering Education' by Prof G R Damodaran and Dr M C Vaithilingam; (2) 'Forecasting Techniques' by Dr Gulab Singh; (3) 'Non-Formal Education in New Specializations' by Dr O P Gupta; (4) 'Rural Engineering' by J G Dahigaonkar; (5) 'Educating the Engineer of the Future in the Emerging Profession of Quality Engineering' by R N Bosu; (6) 'Quality & Reliability: a Newly Emerging 'Discipline' of Technology' by S N Agarwal, Prof S Saran and A K Yadav; (7) 'Educating the Engineer of the Future in the Newly Emerging Branches of Engineering---Water Pollution Control' by V H Kulkarni; (8) 'Need for a New Discipline---Architectural Engineering' by Sheodan Mal; (9) 'On the Inclusion of Systems Theory as a Core Subject in Engineering Curriculam' by Jayanathapal; (10) 'Educating the Systems Engineering of the Future' by V V Athani; (11) 'Shape of Engineering Education in 2000 AD with reference to the Evolution Process of the System Itself' by Dr S Prasad; and (12) 'Appropriate Technological Education' by Dr R Nagaraja.

Educational planning systems of evaluation and manpower estimations and scenarios were considered in Group B which was chaired by Prof A K Rao of the Indian Institute of Science, Bangalore. Papers included for discussion were:

(1) 'Modelling Engineering Education for Future' by Dr S M Sulchija and Dr Arora; (2) 'Educating the Engineer of the Future' by S N Sharma; (3) 'Non-Formal Approach to the Dissemination of Engineering Knowledge' by B N Nityanandan; (4) 'Extension—a Non-Formal Approach' by Prof R G Janakiraman; (5) 'Training the Faculty for Educating the Engineers of the Future' by L C Chitnis; (6) 'Educating the Electrical Engineer of the Future' by Prof Om Prakash; (7) 'Educational Strategy for the Mineral Industry—a Forward Look' by A K Ghose and Prof R D Singh; (8) 'Future Trends in Metallurgy and Materials Education' by Dr G S Upadhyaya; (9) 'Surveying Education' by G S Kumar; (10) 'Hydrologist and Social Scientist: Collaboration Avenues' by G Krishnaswamy; (11) 'Interaction Between Engineering and Social Sciences' by Dr S N Bhattacharyya; (12) 'Interaction with Social Sciences Essential for Progress of Engineering' by J P Datta; (13) 'Interaction Between Engineering and Social Sciences' by S D Dave; (14) 'Some Strategies for Engineering Education' by S C Gupta, R K Mehrotra and B S Varshney; (15) 'Planning of Engineer Education an Integrated Approach' by Maj-Gen P R Puri, Dr H C Parameswar and Lt-Gen P M Lokhande; (16) 'Out-Turn of Engineering Personnel by Professional Societies' by Dr B K Nayar, R K Nandy and S R Das; (17) 'Educating the Engineer of the Future' by Prof V G Garde; (18) 'Educating the Engineer of the Future in Newly Emerging Branches of Engineering—a Case Study: Agricultural Engineering' by R K Sivanappan and K R Swaminathan; (19) 'Reorganization of Engineering Education to Cater to Needs of Newly Emerged Fields of Engineering in Government Departments and Industry' by J S R Mohan Rao; (20) 'Special and Technological Scenarios in 2000 AD' by L N Misra; (21) 'Towards Tomorrow with a New Awakening on a Low Entropy Engineering Education for Low Entropy Technology' by Dr G P Chatterjee; (22) 'Engineering Community—a Catalyst for Development of India in the Twenty-First Century' by T N Misra; (23) 'Entrepreneurship in Curricula of Engineering Studies' by G N Bhatt; (24) 'To Feed India in 2000 AD' by T Ramasarma; (25) 'Educating the Future Engineer' by S K Parikh; (26) 'Training of Engineers in UP' by A C Chaturvedi; (27) 'Technical Education for Industrial Career' by B N Maller and T Gangopadhyaya; and (28) 'Reflection on Management of Technical Education' by Dr P S Rao.

Brig V Nagabhushan (F), Chairman of the Electronics and Telecommunication Engineering Division and Commandant, Military College of Electrical and Mechanical Engineering, Secunderabad, chaired Group C, which dealt with the papers concerning educational systems and technologies. Papers scheduled under this Group were: (1) 'Educating the Engineering of the Future in Traditional Branches of Engineering' by N R Dave and N V Vasani; (2) 'Group Study Method' by S D Tase; (3) 'Continuing

Technical Education—an Overview' by Prof G R Damodaran and Prof G P Rao; (4) 'Continuing Education for Engineers for the Future' by S K Roy; (5) 'Continuing Education as an Appropriate Mode of Educating the Future Engineer' by Dr B K Sthapak and D G Motwani; (6) 'Short-Term Courses for the Continuing Education of Future Engineers' by D D Misra; (7) 'Part-Time Post-Graduate Education of Engineers' by Dr N L Kachhara; (8) 'Organization of Laboratory Instruction in Engineering Education' by Dr G K Dubey; (9) 'The Role of Workshops in Shaping the Future of Engineering Education' by M A Manan; (10) 'Educating the Civil and Structural Engineer for 2000 AD' by B T Unwalla; (11) 'Systems Approach to the Design of Education and Training Systems' by Prof V Natarajan; (12) 'Education in Environmental Engineering' by Prof S K Gajendragadkar; (13) 'On the Importance and Necessary of Nuclear Engineering Education' by Om Pal Singh; (14) 'Role of Transportation Engineering Education for Engineers of the Future' by Dr S K Khanna, Dr M G Arora and S P Bindra; (15) 'Continuous Education of Engineers in Future' by N S P Chawala and N K Ahuja; (16) 'Continuing Education for Mechanical Engineers of the Future' by R L Agarwal; and (17) 'Training and Manpower Development for a Nuclear Power Station' by P Ramalingaiah.

At the eighth session, chaired by Shri T N Subba Rao (F), Managing Director, Gammon India Ltd, two theme papers were presented: Prof C N R Rao of the Indian Institute of Science, Bangalore, dealt with 'Education in Basic Sciences for 2000 AD' and Prof O Mukedkar (F) of Concordia University, Montreal, Canada, dealt with the topic 'Challenges of Electrical Engineering Education in the Twenty-First Century'. This was followed by a panel discussion in the afternoon on the theme: Educating the Engineer of the Future in Developing Countries. Prof U R Rao, Director of ISRO Satellite Centre, Bangalore, was the Chairman.

At the concluding session of the Seminar, presided over by Lt-Gen J S Bawa, the Group Convenors, Convenors of the Regional Round Tables held in various State Centres prior to the National Seminar and Sm S Balaraman, Project Director, IIT, Madras, presented their reports. Prof N S Ramaswamy, Director, Indian Institute of Management, Bangalore, also spoke on the theme of the Seminar with special reference to appropriate technology. Detailed recommendations were arrived at the Seminar.

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PROCEEDINGS OF THE NATIONAL SEMINAR ON 'EDUCATING THE ENGINEER OF THE FUTURE'
JANUARY 7-10, 1979, BANGALORE

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* Texts not available

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BACKGROUND NOTE

Dr P N Murthy, Fellow
Professor of Aeronautical Engineering, IIT, Kanpur

Convenor, National Seminar on 'Educating the Engineer of the Future'

RATIONALE

In every society the technologist and the engineer form important units; all ideas generated by various sources are given concrete form by them. They mould the natural resources into forms for use. They are important links in the growth of material prosperity and development.

The education of an engineer is essentially a system for developing the necessary skills to perform the above societal role. This is apart from the liberal education that should be provided to everyone to enable him to understand his place in society, develop a harmonious relationship with his neighbourhood and achieve for himself and the society a measure of happiness consistent with the value systems. Such education is meant to reduce the incompatibilities between individual and social goals. Consequently it has to be broad and humanistic, giving spiritual insights into himself and an appreciation of the social dynamics. It should help him to find his role and position in the social complex. Technological education, on the contrary, has a less complex and more direct objective of developing skills for harnessing material resources for social prosperity. It can thus act as an instrument of change. Any failure in this educational process and planning can have disastrous effects on the future of society.

The level and nature of the skills depends considerably on the social organisation, the level of prosperity already attained and the achievements of science and technology. There is almost a direct relationship between social requirements and generation of skills. Any incompatibility or wrong understanding will lead to unemployment, loss of productivity and reduced growth with accompanying technological dependence on other countries. A sluggish economy cannot motivate or sustain a high level of engineering skill. Nor can an unmotivated and ill-equipped engineer help the growth of development. Further, a primitive technological society cannot absorb post-industrial technology without some undesirable and, quite-often, violent perturbations in the social set-up and culture. Nor can post-industrial technology be avoided if a backward economy is to be pulled through to levels sufficient to give a resonable quality of life to the people. New technologies have, therefore, to be introduced smoothly into a relatively uninformed society with a developed culture.

TARGETS

India had embarked on the path of development over three decades ago. It is now among the first ten industrialized nations. It is the third largest in terms of trained manpower. While these are tremendous achievements, much needs to be done before everyone of its citizens gets adequate basic amenities. One can get an idea of the present stage of our development by referring to some of the indices of development proposed by several agencies as measures of the levels of prosperity. It is now fairly well recognized that the GNP is a poor indicator of the overall development. The Physical Quality of Life Index (PQLI) suggested by the Overseas Development Council of the USA gives a number 40 for India while Sweden, the USA and the UK are close to 100. Surprisingly, even the rich oil nations, having a GNP of the level of the USA, also have only an index of around 40. A more rational index seems to be the one developed by ASHA[1]. It is given by

$$\frac{\text{Growth Rate} \times \text{Employment} \times \text{Literacy} \times \text{Life Expectancy}}{\text{Birth Rate} \times \text{Infant Mortality}}$$

The index neatly identifies four groups among the world nations as: (i) Low income group with an average ASHE index of 43; (ii) Middle income group with an index of 341; (iii) Upper middle income group with an index of 594; and (iv) High income group with an index of 10470. It suggests for India an objective of 2023 to be attained by 2000 AD. This value of the index means a growth rate of per capita GNP of 3.5%, employment of 850 per 1 000, literacy of 850 per thousand, birth rate of 25 per 1 000, infant mortality of 50 per 1 000 and a life expectancy of 70 years. Even though these targets are modest, to pull from ADI of 43 to 2023 requires massive effort and a total application of science and technology at various levels. The role of engineers in this gigantic task is, therefore, going to be primal. Only an extensive debate, intelligent planning and dedicated effort can enable identification of tasks, deployment of resources and execution of the plans. To start the debate on all these issues is the primary aim of this National Seminar.

AREAS TO BE EXPLORED

As stated earlier, engineering education becomes infructuous if it is not properly matched with the skills required. The first exercise should therefore, be to identify the types of technologies required. The rate of growth of industry, defined broadly, will determine the skilled manpower required. Attempt should be made to match the manpower generation with the requirements of industry. While it may not be possible to make exact estimates, as reasonable forecast should be made both to avoid manpower famine as well as unemployment. So, projection for manpower is the next part of the exercise. Evidently, efficient techniques for generation of this manpower with proper awareness of the time dependence of these requirements and the contents of the technological programmes should be debated extensively and in depth to give a concrete form to the ideas. Broadly then, the four items that should receive the attention of technologists, industrialists and educationists are:

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[1] S Ramakrishna, T Rama Sarma and K I Vasu. National Paper of a Typical Developing Country. Association for Application of Science to Human Affairs (ASHA), Indian Institute of Science, Bangalore 1978.

(i) Types of technologies to be developed in 2000 AD
(ii)The manpower requirements
(iii)Techniques of generating this manpower
(iv)The contents of the technological programme

FUTURE SCENARIO

Discussion of these problems has to be done in relation to the life styles and scenario at the turn of the century. An important feature of life at that time is the tremendously large number of people that will be inhabiting this planet. Considering approximately one-seventh share of this population, India will have about 950 million people. Even providing basic amenities, as projected by ASHA Development Index, will be a stupendous task, needing the services of almost every available human resource and harnessing of all material resources.

The NCST base paper on 'India in 2000 AD'[2] forecasts glaring shortages in every area in 2000 AD. The shortfall in foodgrains is estimated to be 87.3 million tonnes, in oilseeds 32 million tonnes and in sugar about 12 million tonnes. Similar is the case of milk, meat and eggs. In housing, the shortage is likely to be approximately 50 million. Energy requirements are estimated to grow by 10, 5 and 13 times over the 1970-71 requirements in coal, oil and electricity, respectively. Large scale industrialization will render the environment hostile for healthy living unless proper antipollution measures are taken.

The picture therefore is quite staggering and the problem looks formidable. Is this picture inevitable? Can there be an alternative scenario which can be our preferred future? Is the country so helpless as to leave its future to the inexorable laws of history? Did we understand the process correctly? While civilizations have dwindled and vanished in the past, should it happen now with the type of planetary civilization which is being evolved by humanity?

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[2] First Draft of the Base Document on Futurology: A Discussion Paper. NCSI Panel on Futurology, 1976.

All these questions have to be answered, understood and assimilated. anything that contributes to the survival of all with misery to none should be our goal. A scenario, then with this as the objective should be conceived, projected and furthered. Political will and social action will have to usher in this era. Science and Technology whould be made to act as the material instruments of this happy journey into the future.

TECHNOLOGIES REQUIRED

What then are the technologies required to achieve thisgoal?

Among the many aspects involved in the answer to this question, two of them stand out: (a) size of the population, and (b) their distribution. Whatever may be the scenario, whatever may be the social organization and its basic guiding philosophy, we have to place a limit on our rate of population growth. While it is true that every additional human being means two additional hands and one additional brain, to add to prosperity, it is valid only if the hands are strong and the brain is well nourished to be able to think. Poverty generally tends to breed poverty if numbers are not checked to enable a higher share from the wealth. Such a check cannot be effective if it is not supported by understanding. Education, to develop social will and medical research to provide the control technology have therefore to play a great role in this enormous task. Both these require technologies - educational technology for mass education and communication and medical technology to bring medical research to practical application.

Where we live and how we live is the next point of interest. In 2000 AD it is expected that 30% of our population will be in urban areas and the rest continue to live in villages. In terms of absolute numbers these are huge. Consequently the focus, as it is now, still will be predominantly on rural development. Otherwise a vast majority of people will remain untouched by the fruits of development and the momentum of change. They will then become a drag on the pace of growth and unless they are brought into the mainstream, the country cannot move forward to it tryst with destiny. How do we achieve this? Evidently this cannot be by the methods and motivations of the present which involve a massive migration from the rural to the urban areas. To-day this is happening because of the vast disparity between opportunities and life styles in urban and rural areas. This disparity is obviously both unfair and dangerous, halting the pace of growth. Can we reverse this trend and maintain the growth rate?

The anwwer to this question has to be in the affirmative since a negative answer is not acceptable. Any answer should provide the employment incentives in the rural areas. Work must be created for the able bodied people wherever they are and as they are. This again means imparting skills and utilizing the skills in their own environment without a violent disturbance in their value systems. An awareness of this approach is evident in the frequent use of the words like 'rural technology', 'appropriate technology' and phrases like 'small is beautiful'. While the spirit in these is understandable, they should not be understood to mean low productive technology. It should not be understood to mean low productive technology. It should mean development of decentralized modular technology to create small and efficient units of production to generate employment and wealth. Every housein a village should become a unit of production either as an ancillary to a big industry or as a unit of a factory. Agriculture too should be organized like an industry.

To provide for all that is required to improve the quality of life of our countrymen, a heirarchy of technologies are required. A systems approach to the problem will indicate that technologies of various levels and sizes and industrial organizations of several kinds and sizes are required. If, for example, food production is to be raised to the level of self-sufficiency, simultaneous use of green manure, chemical fertilizers and compost will have to be encouraged. It can be seen that each one requires a different approach. Optimal cost-effective production of chemical fertilizers can be done only through centralized large scale production, while compost is localised by nature. Similar is the case with energy. The NCST Futurology document[3] recommends the use of biogas plants as well as installation of large 500-1000 MW units to meet the power needs. In addition it recommends the development of non-conventional energy sources like solar, wind and geothermal sources since it is expected that 21st century would begin with the prospect of power systems mainly based on solar energy, supported by other regional non-conventional energy resources such as tidal, wind and geothermal, Further it recommends that R & D should start now in MHD, fluidized bed and dual cycle technologies. One cannot, therefore, make a blanket statement that our country requires only low or intermediate and not high technology. High technology is generally feared to mean industrialization with no human values. This is no more true in this case than in the case of other level technologies. Much depends on the value systemsadopted by the society. It can be expected that future societies will be forced to adopt an idealist view of life for survival if not by conviction.

It turns out, therefore, that we need all types and levels of technology, The focus or aim, however, should be to generate wealth with full employment,to generate wealth with an inherent system to avoid concentration of employment and wealth whatever may be the sector, if we want to take care of the millions of mouths and convert all hands into resources. Massive problems need innovative and sophisticated solutions. India has missed the industrial revolution, it should not miss the technological revolution[4]. It has to frog leap and accept the best technology, whatever be its price, if it is socially relevant to Indian conditions[1]. What then are the required technologies? While precise identification may not be possible in every case, a broad identification must be done for action now. One should, however, bear in mind that progress cannot be a step jump. It can at best be along a steep curve. Whatever we do should, therefore, integrate with the traditional patterns of craftsmanship and areas of technology.

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[3] An Outlook for India's future (2000 AD) : The first draft of Integration Document: A Discussion Paper, 1977.
[4] Ibid, p 4.

Even today there are many new disciplines emerging to sope with the existing problems and incorporating the advances in science and technology. To list a few, with the growing size of our metropolitan areas, urban systems is fast developing into an area of serious study. It involves many disciplines starting from social sciences to industrial engineering, transportation, etc. With rapid industrialization and increasing transport operations, pollution of many sorts is posing a problem. Environmental engineering is consequently being developed to design and control our environments. Understanding the human system has become essential to deal with the stresses and strains imposed on the physical system due to complexities of modern life. The field of bio-engineering is emerging as a speciality in its own right. The advances in electronics are staggering. With today's microelectronics and satellite communication systems, will communication in 2000 AD approach the level of ESP? With skylabs and space stations will space cities be a reality? Are we going to generate power in space with 5km long and ½ km wide solar arrays and laser-beam it to earth? will moon become an industrial ancillary to the earth? The technological scene is thus changing fast, posing new challenges. We must meet them with ingenious solutions.

MANPOWER

Implementation of plans in various sectors needs adequate and well trained manpower in relevant technologies. Today there is considerable criticism from industry that they are not getting the right type of manpower, that our graduates and technicians are not trained in practical terms and are thus insufficiently prepared. While a part of this criticism is true, it should also be recognized that our industry has not tried to get out of the licensed production stage in several areas and our engineers do not feel the jobs challenging. Even in the case of age old industries like textiles, jute, cement, building, railroads and sugar, we have not entered into the era of research and development and original designs. Even maintenance has been on the lines designed by the principals abroad. This situation is now slowly changing. Our industry is trying to base its activities on original designs and research and development. Correspondingly the challenges to the employed graduates and technicians are also increasing.

Any industry has need for several kinds and levels of skills to carry out its manufacturing and marketing programmes. All these have to be identified carefully in consultation with industry with vision and perception. While precise projections may not be possible, at least a broad idea must be obtained to enable organization for the generation of this manpower.

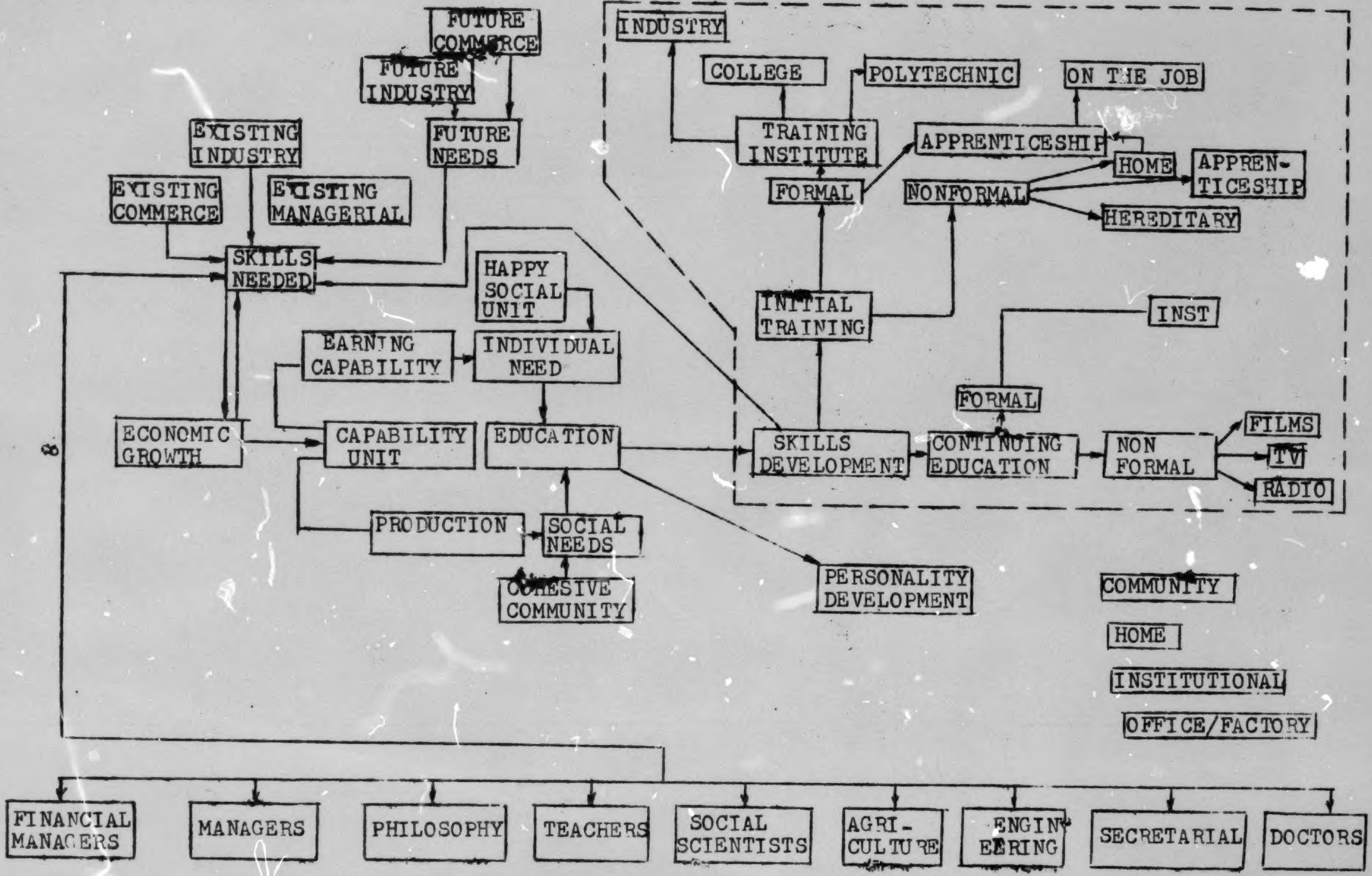
By a simple guess one can say that this manpower requirement will be very large. The two problems are: (i) projecting the manpower requirements, and (ii) training for these skills. While the former is not easy, the latter involves many difficult problems. What then are the methods of achieving the goals?

TECHNIQUES OF TRAINING

Education is a total process and a complex multiobjective system. The two primary objectives, however, are: (i) to develop personality, and (ii) to develop skills. Even though our concern now is with the second, technologically education cannot be totally alienated from the rest of the educational process. The total system is indicated in Fig 1.

The block enclosed in the dotted rectangle indicated the methods of training and converting human beings into resources. These require special techniques to be developed in terms of educational technology on a massive scale. Particularly on the nonformal side, the field is almost new to the country. On the formal side considerable review, revision and reorientation is required to give the developmental bias. Even now, new schemes are being tried like sandwich system, practice school, etc, to make the engineer more relevant and reduce the period of probation before he can contribute to production and other developmental activities in the industry. One can expect from the nonformal schemes a very large group of people who are simultaneously learning and earning, improving themselves as well as contributing to production in real terms. This can be expected to form the major group in the total workforce. A thorough understanding of these techniques and processes is required to plan for the educational network consistent with the workforce requirement. The distribution between various modes is another problem to be solved.

Evidently, total deinstitutionalization of technological education is impossible. Some disciplines are not amenable to nonformal transmission. This is so particularly in high technology areas like space sciences and technology, MHD, computer systems nuclear sciences and technology, etc. In these a close interaction between the teacher and pupil as well as centralized laboratory facilities are essential to give the right knowledge and emphasis. Even non-formal education will contain by necessity certain formal component.


FUTURE COMMERCE
FUTURE INDUSTRY
FUTURE NEEDS
EXISTING INDUSTRY
EXISTING COMMERCE
EXISTING MANAGERIAL
SKILLS NEEDED
HAPPY SOCIAL UNIT
EARNING CAPABILITY
INDIVIDUAL NEED
ECONOMIC GROWTH
CAPABILITY UNIT
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SOCIAL NEEDS
COHESIVE COMMUNITY
PERSONALITY DEVELOPMENT
INDUSTRY
COLLEGE
POLYTECHNIC
ON THE JOB
TRAINING INSTITUTE
APPRENTICESHIP
HOME
APPRENTICESHIP
FORMAL
NONFORMAL
HEREDITARY
INITIAL TRAINING
INST
FORMAL
SKILLS DEVELOPMENT
CONTINUING EDUCATION
NON FORMAL
FILMS
TV
RADIO
COMMUNITY
HOME
INSTITUTIONAL
OFFICE/FACTORY
8
FINANCIAL MANAGERS
MANAGERS
PHILOSOPHY
TEACHERS
SOCIAL SCIENTISTS
AGRICULTURE
ENGINEERING
SECRETARIAL
DOCTORS

Fig 1. EDUCATION AS A SYSTEM TO DEVELOP PERSONALITY AND SKILLS

Identifying the areas for predominant non-formal and formal trainings is therefore necessary.

CONTENTS OF PROGRAMMES

All, what was envisaged in the earlier sections, cannot be achieved unless the contents of the programmes are clearly laid out. As stated earlier, there is a constant complaint about the type of gradautes coming out of the institutions. Industry says, that our graduates have no appreciation for practical situations. This is perhaps true up to a point. Many of our children do not have prior contact with anything mechanical or electrical. This lacuna was difficult to fill with the poor industrial culture that existed till the present times. The scene is changing and our people are becoming familar with industry, high speed transportation and other products of industrial revolution. One can, thereafter, expedt a better appreciation of things from a practical design and operation point of view. In any case, training on the job in the industry cannot be eliminated. Also the fast changing post-industrial technology, every technologist and engineer will be forced to learn new things through continuing education. His equipment for this will be the core knowledge that he has acquired during the initial graduate days. His strength will be the ability to think and analyse new situations, a capability which he is expected to acquire during his graduate training. How do we design this core? How long will it take to impart this? What system should be adopted to develop the practical feel for design? How do we teach the topics like maintenance engineering? What should be the theoretical and practical content of the programme?

FACULTY GENERATION

Imparting education is both an art and a technique. While everyone has some ability to articulate his thoughts teaching requires the articulation of ideas to initiates who are new to the field. So there must be an aptitude for it. Average teachers can be trained but good teachers can be acid to be made. Further, much depends on the pupil who should be willing to receive. Not everyone is willing to learn everything. This throws up the question of the aptitude of the student. How to determine this? How to identify and train teachers who can bring out the full facultles of the students? Even if the teacher student ratio is 1:10, the number of teachers required in 2000 AD will be 2 million which is not a small number.

EVALUATION SCHEMES

The total process of education consists both of learning and evaluation. It is well-known that the present evaluation system is under severe fire from all quarters. The reason is essentially the mismatch between the manpower needs of industry, the training programmes and the huge unemployment. While it is true that most of the engineers tend to do jobs which are very different from their original training, this is expected to occur only after a very long professional career.If this happens at a very early stage in the career, the adjustments will become very difficult. The performance in the college will have little bearing on his success as an engineer. How are we to eliminate this problem?

Evaluation is meant to judge the level of competence achieved and amount of knowledge acquired by an individual. A degree is supposed to indicate this. It reflects a certain programme that has been gone through by the candidate and the level attained by him. Being a normalized programme it may contain many components that are not required for a given purpose. Should we then waste the time of a student insisting on his going through the entire programme even if he does not need a part of its in future. This is a difficult question to decide. Should degree be required for employment? Instead of an impersonal body like Government or University evaluating the candidate, can the employer conduct the evaluation for his specific purpose? The student willtake course in a 'cafeteria' type system and present himself before the employer. The university will thus be a body offering knowledge. It will not evaluate. Can this be a less exacting and less wasteful system allowing the aptitudes to play a predominant role?

CONTINUING EDUCATION

Education is a continuous process. If one cannot learn in a real life environment, he will become a drag on progress. Every new situation has something to teach, if one exercises his intellectual abilities. However, there is a need for formal refresher course to acquaint practising engineers with latest developments in relevant areas. How are these to be organised? Should there be a licensing system for engineers which prompts them to renew them with fresh inputs?

CONCLUSION

Thus to plan the education of the engineer of the future, one should know what type of world is he to operate in? Scenarios have to be conceived, evolved, delineated and debated, to know his environment of the future. Consistent with this the technologies in which he is to be trained have to be identified. To achieve the prosperity level and quality of life the technological manpower required has to be estimated. Through formal and non-formal methods this manpower has to be trained.

This effort involves answers to many questions posed earlier. These questions are difficult and there are no unique answers. However answers have to be found. New situations are always difficult to face, particularly so when the scene is changing fast. Any educational system anywhere in the world proved to be a slow system with long reaction and response times. This characteristic will not create any social problems provided the basic needs of the people are somehow taken care of. In the early years of their development, the western world had this advantage. It is being lost now and the pressures and compulsions of the future are causing strains in their systems though not with the same intensity as in our country. Our problems are manifold. This standard living and consequent urgency for growth is placing heavy burdens on our ingenuity to engineer the change.

Our society today reflects all the ills and problems of the world. Any solution and success achieved here will affect the whole world. The present problems of our country are massive in nature and are likely to continue in future. With a 'second India' added in the next twenty years, a solution for these requires a basic, qualitative change at the fundamental level in man, and the forms, symbols and contents of his organizations. This is not easy to come by. One can only hope that the present confusion and contradictions contain the seed of solution for the future set-up.

The future educational system should aim at social growth and individual spirituality. Technological skill enlivened and motivated by the all-transcending human spirit constitutes the human resource. The development of this should be the goal of the system. The task is to shape and harmonise material and spiritual, social and individual values for the making of a new society. In this the technologist with human values is a major participant. He must be trained to play this role.

BASIC DOCUMENT

INTRODUCTION

The subject of future Research is both difficult and uncertain. Even then there is already extensive research done in futurology by many bodies. In all futurology studies, a multidimensional view focussing economic, social techrclogical and managerial aspects have to be considered while examining the dimensions of various problems that will prevail in future.

It is resonable therefore, that arising out of various studies by these thinkers will emerge practical approaches for handling current situation effectively and overcoming the challenges that the future will pose.

In every society the technologist and the engineer form important units; as ideas generated by various sources are given concrete form by them. They mould natural resources into forms for use. They are important links in the growth of material prosperity and development.

The futuristic studies undertaken by various agencies have made certain predictions. All these studies have emphasized that approaches to the problems in future will have to be radically different from today's conventional approaches. Dr Sam Nilsson, while undertaking such a study for the Federation of Institutes for Advanced Studies - Stockholm, has underlined the concept of inter-dependence between nations. He has predicted the need for a truly global society in an economical, cultural and technological sense. These studies have also covered analysis of the global trends for essential resources like food, land, water, fertilizers and energy.

On the Indian front it has been predicted that by the year 2000 A D the Second Indian population will be added, which will pose dimensions and challenges of securing more meaningful lives for more than 1000 million people and identifying courses of action open to the national. This situation will automatically generate additional problems in areas such as food, housing, transport, communication, energy, water, employment, ecology - environment, pollution, etc. We, therefore, need to make an assessment of both material and human resources available. Superimposed on this we will have to assess the use of conventional technologies and non-conventional technologies.

The situation demands considerable emphasis on innovating new ideas and working with social scientists in tackling human problems of the large masses which entails changes in the value system. Indian technology will have to adopt this as a philosophy of action, if it is to serve the masses and rural areas in general.

BACKGROUND

The liberal education that should be provided to everyone to enable him to understand his place in society, develop a harmonious relationship with his neighbourhood and achieve for himself and the society a measure of happiness consistent with the value systems. Such education is meant to reduce the incompatibilities between individual and social goals. Consequently it has to be broad and humanistic, giving spiritual insights into himself and an appreciation into social dynamics. It should help him to find his role and position in the social complex. On the other hand, technological education has a less complex and more direct objective of developing skills for harnessing material resources for social prosperity. It can thus act as an instrument of change. Any failure in this educational process and planning can have disastrous effects on the future of society.

These challenging tasks raise in one's mind a large number of diametrically opposite ideas and view points - a situation which we often observe in our day to day life as can be seen from following examples -

(a) A primitive technological society cannot absorb post-industrial technology without undesirable and quite often violent perturbations in the social set-up and culture. Nor can any post-industrial technology be avoided if a backward economy is to be pulled through to levels sufficient to give a reasonable quality of life to the people. New technologies have, therefore, to be introduced smoothly into a relatively uninformed society with a well developed and advanced cultural bond.

(b) In the current pattern of education of the engineer we are experiencing similar diametrically opposite views wherein on the one side we have unemployment of engineers and skilled persons and on the other the industry is complaining about non-availability of appropriately and well trained engineers.

(c) In the rural areas we have a vast scope for applications of engineering but we neither have an appropriate technology developed nor suitably trained manpower for its application.

It is with this background that the Institution of Engineers (India) is organizing this National Seminar on 'EDUCATING THE ENGINEER OF THE FUTURE' where we shall have to answer ourselves many complex, multi-dimensional questions.

TECHNICAL EDUCATION IN THE NEXT DECADE

The Government of India had in 1977 appointed a high level working group on technical education to recommend the changes in technical education for the next decade. The recommendations of this group have highlighted the following major points -

- Present man-power supply is adequate - but there is a need to increase efficiency and effectiveness.
- New courses to be based on well defined man-power needs
- There is need to modify courses/programmes.
- Technical education should take problem/application oriented programmes to facilitate substantial contribution to rural and community development.
- Polytechniques should act as focal points to promote transfer of technology to rural community.
- We should promote advanced technicians programmes.
- Senior appointments should be made on Contract Basis and faculty should be drawn from Industry also.
- Short courses should be arranged for teachers in Educational Technology.
- There should be a single agency to man technical education from craftsman to Post-Graduate.
- Adoption of polytechnics by industry should be encouraged.
- Plan Allocation should be commensurate with development layout of user departments.

These recommendations call for a radical change in our education policy and we will require to drastically modify courses and programmes of technical education.

TECHNICAL EDUCATION FOR 2000-2025 A D

When one looks at the remote future the identification of future becomes little difficult. If one has to go by the futurologist predictions in the past and actual happenings, one will observe that the problems India would face for the year 2000-2025 are likely to be totally different from the current problems.

We have to plan today for meeting the objectives of the years 2000-2025. Changes in education process will have to begin around 1985, so that those who graduate after 1985-1990 are geared to a new outlook. We may have to motivate this group of engineers to be innovative and desirous of change for the better. (The word Engineer should cover technologists, such as research engineer, doctorates, graduate engineers, diploma holders and skilled technicians).

FUTUROLOGY STUDIES

The futurologists who have ventured to predict trends for the year 2000 and first quarter of the 21st century have differed considerably. Number of studies of this nature have been taken in hand from time to time by various groups. These studies indicate that we may differ in details but should be in a position to evolve the trends of the future scenarios and hence plan the education pattern for the engineer of the future.

All these studies have converged into a single thought viz approach to the problems of the year 2000-2025 will have to be imaginative, innovative, adoptive and multi-disciplinary to help us to meet the future challenges. Hence the problem of educating the engineers of the future would also need unorthodox and highly unconventional methods and technologies. The NCST Panel has suggested a dual approach to technology development-

i) develop indigenous technology and apply technology appropriate to our situation, and

ii) break new grounds and take recourse to highly sophisticated technology in selective areas.

Salient features of some of these studies have been dealt with in the following paragraphs.

U.N. World Plan of Action

The United Nations' World Plan of Action for the application of science and technology to development brought out the following salient features -

i) There is need for building up of Scientific and Technical Institutions to make best use of science and technology in development.

ii) We will have to attack specific problem areas through various UN agencies to speed up process of development.

iii) World Development can be brought about by sharing benefits through trade, aid and transfer of modern technology and by providing sufficient trained manpower and social psychological climate and infrastructure.

iv) World Plan of Action has listed areas for research, for use of existing technology and for building indigenous Science and Technology.

v) Some of the important areas for consideration listed in the Action Plan are Development of Tropical Hardwoods & Fibres, Ground Water and Arid Land, Desalination, Natural Disaster Warning Systems, Indigenous R&D, Storage and Preservation of Agricultural Produce, Housing Construction Methods, Improvements in Secondary Education, etc.

Predictions of Technological Innovation

Herman Kahn and A.J. Wiener have predicted 100 probable technological innovationsin the developed world by the end of this century. Generally, it is true that in India - by 2000 AD - we shall be using the technologies already developed so far and implemented in the developed world today. A look at these predictions and close analysis of world progress can help us to study and evolve possibilities of using some of these technologies for meeting our gigantic problems particularly by resorting to transfer of technology or use of totally imported technology if necessary.

NCST Studies on Futurology

Various studies undertaken by different agencies in India and the comprehensive work undertaken by NCST Panel on futurology highlight many significant area nearer home. NCST study brings out relevance of futurology to the Indian context, present status and problems of Indian conditions. It focusses our sttention on details of preferred futures and task ahead particularly in respect of technology choices, whilst giving due weightage to social attitudes and quality of life.

The study has brought out preferred likely future, possible likely future and suggests approach to technology in following specific sectors -

* Public Transport

* Housing

* Resources and Material

* Energy

- Food
- Agricultural System
- Need for Conservation
- Communication
- Education
- Management

This study gives us in more concrete terms Indian scenario in the year 2000 AD. It highlights that the greatest problem we will face is the problem of increasing numbers and decreasing supplies.

ASHA Philosophy

The study of a development process of a country and physical quality of life was undertaken by the Association for Application of Science to Human Affairs (ASHA). In a paper prepared for the United Nations Conference for application of Science and Technology for development ASHA has highlighted a different philospphy for concept of development and physical quality of life. The study suggests that one need not go by the measures of absolute conventional norms (such as GNP or Per Capital Income) for evaluating development of a country - a method as applied by the developed countries. A country can maximise use of existing resources to improve the physical quality of life with minimal inputs of resources and energies to achieve minimum standards of living for majority population. This philosophy is of special significance to the developing countries. This study has also highlighted the need for judicious use of technology transfer, need for use of highly sophisticated technology in specific areas, role of education and the probable future approach for education.

Bombay Management Association Studies

The Bombay Management Association had organised a Seminar on Futurology and had brought out Management Perspectives - Studies in Futurology - 2000 AD. This perspective identifies following specific task giving dimensions of the problem that would be applicable to India in the year 2000 AD and of specific relevance to this seminar -

- There will be a Second India added.
- If we have to provide housing to the majority of our population, every year 5.4 million homes will have to be built.

- 274 million tonnes of food grains per year will be required against current production of 100/120 million tonnes.

- 37 million tonnes of food grains per year will be required against current production of 10 million tonnes.

- 183 million tonnes of cement per year will be required against current production of 15/20 million tonnes.

- 200 million tonnes petrol consumption will be required against current consumption of 25/30 million tonnes.

- Water will become the biggest scarce resource and we may have to convert the deserts of India into tracks of cultivable land, if not gardens blooming with flowers and fruits through the process of desalination.

- The labour force will grow by 238 millions between 1971 and 2000.

- The percentage share of agriculture will decline from 77% in 1971 to 73% in 2000 and hence the labour force seeking work in agriculture will grow by 166 million and that in non-agricultural activities by 77 million.

- All villages in India will not be electrified before 2000 A D.

- The irrigable area potentiality in India is estimated at 107 million hectares. By 1975 the area under irrigation has been only 30.3 million hectares. At the current rate India may require over 150 years to reach the target potential of 107 million hectares.

- On the food front we may have to evolve a cheap diet sufficient in calories and proteins from the nutrition point of view.

- On the energy front it is envisaged that coal is going to be our prime source of energy.

- The advent of 21st century would emerge with new energy sources, such as solar, wind, tidal and geothermal. Immediate actions are required to be outlined and to initiate sustained consistent R&D efforts in these fields.

Summary

Science and Technology will dominate the lives of people. There is likely short supply of almost every consumer commodity, of power, of water, of food, of space, of housing, etc. Social values will change including the system of family and marriage. Interdependence between countries will increase. World government may be taking shape.

On Indian front, forecasting the rate of technological change has been much more beyond the reach of imagination. This calls for deeper introspection on choice of technology, scale of production and relocation of industry. Often social implications resulting from technology, i.e. technology assessments have been left in the background. We will therefore have to study the futurologists' predictions about new and current; sophisticated and simple; conventional and non-conventional; appropriate but not intermediate or backward; employment oriented as well as mass production - automated wherever necessary - technologies, and identify our priorities. It is from these technologies that we have to evolve a strategy for educating the engineer of the future.

Imperative to Indian industry, wherever it may be located and whatever be its base, whether industrial or agro, is to make the choice of appropriate science and technology for all those which are available. The benefits of appropriate science and technology will have to be designed to reach the lower economic levels of society both in the urban and rural areas.

The economic challenge before Second India will, therefore, be to find the right priorities, the right projects, the right policies and right technologies. The problem is really in identifying what this right is and how right is right, as Peter Drucker has never been tired of saying 'The key task of management - be it the management of a company or of an economy - is not to find the right way of doing a thing; it is the art of finding the right thing to do'.

Against this stupendous task, the positive side of the current state of art was reviewed. Embarking on the path of development over three decades ago, India currently ranks amongst the first ten industrialised nations. It is the third largest in terms of trained man-power. One can get an idea of the present stage of our development by referring to some of the indices of development proposed by several agencies as measures of the levels of prosperity.

SCOPE OF SEMINAR

For the seminar the scope was limited to education of the engineer. All these changed situations would demand flexibility in the Technical Education System so that workers at the operative level have the opportunity to receive education offered at other levels. Specific recommendations were arrived through the deliberations avoiding discussing in detail the social and technological scenarios and accepting the trends identified by the studies already undertaken by the various futurologists and taking off from there. Similarly, the predictions of technologies required in non-conventional and conventional areas, inter, multi and other disciplines were adopted.

OBJECTIVES OF SEMINAR

From the scenarios brought out by various world and national agencies highlighted above, the Seminar attempted to evolve (develop) -

i) Strategies for achieving the above objectives

ii) Systems approaches to educational problems

iii) Formal approaches to engineering education

iv) Non-formal approaches to engineering education

v) Methods of training the faculty and educating the engineers

vi) Educational technologies

vii) Methods to educate the Engineers of the Future in Traditional Branches of Engineering

viii) Methods to educate the Engineers of the Future in Newly Emerging Branches of Engineering

ix) Strategies for Interaction between Engineering and Basic Sciences

x) Strategies for Interaction between Engineering and Social Sciences

xi) Methods of continuing education for Engineers for the Future, and

xii) An integrated and dynamic planning system for educating the Engineer of the Future.

SEMINAR METHODOLOGY

On the opening day the Institution had invited a number of leading personalities to deliver Keynote Address on the various issues. On the second day, detailed deliberations took place on different issues in different sessions and finally on the third day the deliberations were integrated and specific recommendations were evolved for strategies and Action Plan in various areas for educating Engineers of the Future.

The seminar deliberations had been divided into major groups -

PART I

Part I covered Social and Technological Scenarios, Technology Forecasting and Technology required, Manpower Assessment and Forecasting Educational pattern for future. Deliberations in this part was basically to synthesize their ideas about probable future scenarios and discuss in the light of background given above and detailed in the various Appendices.

PART II

In Part II answers were found to the questions referred in the scope of seminar in general and covered the educational systems, methodology for systems evaluation and methodology for faculty training. It was suggested that this Part be run in parallel sessions so that we could have constructive and positive recommendations evolved in shortest time. Part II was therefore divided in the following topics -

i) Formal education system

ii) Non-formal education systems (problem of educating the masses)

iii) Education for industry - agro based/strategic areas/ industrial products

iv) Education for agriculture

v) Education for service areas (with a main objective of gainful employment of large population of working age group and utilisation of depleting resources)

vi) Educating engineers in newer emerging areas

PART III

Part III summarised the conclusions and recommendations of Parts I and II, and developed a dynamic model for evolving a systems approach in planning the education of the Engineer of the Future.

SPECIFIC TOPICS AND ISSUES

The Seminar document posed some of the questions which we had to be answered before arriving at final conclusions. By no stretch of imagination the questions listed below were claimed to be exhaustive and complete. The document identified some of the major issues we have to face and hence it was hoped that they would be useful to lead the deliberations to specific objectives.

PART I

First Session - Social & Technological Scenarios

The first session therefore dwelled on the assumptions of Social and Technological Scenarios and answered itself the following questions -

i) What is the quality of life going to be around 2000 AD?

ii) Is that future inevitable?

iii) What can we do to reverse the trend if it is needed?

iv) Can we think of a preferred future? (It will be good if some quantitative thinking is presented instead of trying to suggest 'all things for all and everything for everybody')

v) What is the Social system likely to be?

vi) What is the likely demographic distribution?

vii) Can a typical life pattern be described?

viii) What type of economy is likely to operate?

Second Session - Technology Forecasting and Technologies Required

The second session dwelled on Technologies Required to meet the above social and technological scenarios for consumer items, industrial areas, strategic areas, major natural resources, conventional and non-conventional processes and production technologies, inter, multi and transdisciplinary areas and arrived at assumptions based on the futurologists studies and background material given above. The following issues were discussed in this session -

i) Does the technology identified serve the needs of the people?

ii) Does it provide sufficient employment?

iii) Is it a feasible technology in terms of the existing capabilities of the country?

iv) How do we identify a required technology?

v) What are the possible criteria to make a technology relevant?

vi) What steps should be taken now to develop the technology for future use?

vii) How do we assess the technology?

Third Session - Man-power Assessment

The identification (or at least accepting the trends evolved by the futurologist) and evolving assumptions of social and technological scenarios and identification of the type of technologies required could lead us to Man-power Assessment, and in this session answers to the following questions were discussed.

i) What is the extent of the application of an identified technology?

ii) What are the infra-structures required?

iii) What are the skills needed to generate, use and provide extensions series for the technology and its products?

iv) What is the man-power needed for these?

v) Can common skills be developed for groups of technologies?

vi) What is the kind of man-power needed? (engineers, technicians, technologists, researchers, salesman, maintenance engineers, etc.)

Fourth Session - Identifying Educational Problems & Forecasting Educational Pattern for Future

The identification of man-power estimates in different disciplines, different technologies, different skills can then lead us into techniques for forecasting the educational pattern and educational technologies. Before we dwell upon educational technologies we may have to take note of educational problems and answer ourselves the following questions -

i) Knowing the kind of manpower, how do we impart these skills?

ii) What are the steps in training for these skills?

iii) Are traditional, formal methods sufficient to achieve these steps?

If not, can we identify any other methods?

(Consistent with the tremendous tasks, the delegates should not feel constrained by any traditions and inhibitions invisualising the future systems).

iv) What are the resources required for these systems?

PART II

The issues that were discussed for development of strategies were

i) What is the infra-structure needed for development of every one of the above systems?

ii) Can we utilise any existing training facilities like factories, workshops, small and large, for the above purpose?

iii) What is the type of audience and group aimed at in each of the above systems?

iv) What is the period of instruction?

v) What are the modes of training?

vi) What psychological assumptions are made in dealing with the audience?

We then studied the evaluation of educational system and answered the following questions -

i) Has the system been able to communicate the required knowledge?

ii) What is the level and quality of the end product?

iii) How can one assess the quality of the end product?

iv) What are the attributes that one should look for in the end product?

v) Did the end product justify the resources put into the system?

vi) Did the system supply the needs of the industry and society?

The next session dwelled upon faculty training. Some of the questions answered in this area were as follows -

i) What are the attributes of a good faculty?

ii) Should faculty be confined to formal institutions?

iii) Can faculty be trained?

iv) If so what institutions should be built?

v) What should be the commitment of the faculty on the job?

vi) Can working and practising engineers be treated as faculty?

vii) What are the numbers required?

viii) How do we evaluate their training and their contributions?

PART III

We had to answer the following questions in this area -

i) How can we forecast the required technologies?

ii) How do we plan our future educational systems and make them suitable to any changes?

iii) If so, what systems do we plan for?

iv) What kinds of educational systems are identified to serve the future?

v) What do you think are the attributes of an appropriate educational system?

vi) What are the resources required?

vii) What are the components of an identified system?

viii) What are the steps to be taken now to get the system organised?

ADDRESS BY DR P N MURTHY

It is my proud and pleasant privilege to present before you the rationale behind the organization of this National Seminar on 'Educating the Engineer of the Future'. In pursuange of its idea and goals, and as responsible and vital participants in the development of our country, the Institution of Engineers (India) organizes once in two years a National Seminar on important issues of relevance to the national to highlight and focus the attention of the profession and the public on these problems.

Our country is on the march. India, the sleeping giant is waking up, though gradually, to keep up its tryst with destiny. The pains of poverty and the aches of confusion are creating an urge in the vast humanity of this ancient land for a better life. Their desire is reasonable, but the task is enormous.

Our country has embarked on the path of development over three decades ago. It is now among the first ten industrialized nations. It is the third largest in terms of trained manpower. While these are tremendous achievements much needs to be done before everyone of our countrymen gets the basic needs fulfilled. According to the Development Index developed by the Association for Application of Science to Human Affairs (ASHA), Bangalore, we are even now one among the low income groups in the world with an index of 43, the highest being 10 473 of the USA. Even if we can raise our index to 2 023, we will still be having only 85% employment, literacy of 85%, and GNP growth rate of 3.5%. But at least this must be achieved. This is a modest target. However, to pull from ASHA Index of 43 to 2 023 requires massive effort and a total application of science and technology at various levels. The role of the engineer in this gigantic task is, therefore, going to be primal. Even in the past it had been so; it is all the more so in the present age of atom, electronics and cybernetics. He must act as an agent of change. How do we prepare him to educate him for this? Only an extensive debate, intelligent planning and dedicated effort can enable identification of tasks, deployment of resources and execution of plans. To start a debate on all these issue is the primary aim of the National Seminar.

The education of an engineer is essentially a system for developing the necessary skills to perform his societal role. This is apart from the liberal education that should be provided to everyone to enable him to understand his place in society, develop a harmonious relationship with his neighbourhood and achieve for himself and the society a measure of happiness consistent with the value systems. Such education is meant to reduce the incompatibilities between individual and social goals. Consequently it has to be broad and humanistic, giving spiritual insights into himself and an appreciation of the social dynamics. It should help him to find his role and position in the social complex. Technological education on the contrary has a less complex and more direct objective of developing skills for harnessing material resources for social prosperity. It can thus act as an instrument of change. Any failure in this educational process and planning can have disastrous effects on the future of our society.

Engineering education becomes infructuous if it is not properly matched with the skills required by industry, agriculture and other sectors of economy. Today there is considerable criticism from industry that our graduates and technicians are insufficiently prepared to meet their practical needs. While the blame for this situation should be shared both by industry and academics, this situation should not be allowed to repeat in future. The users will have to be actively associated with the educational planning process, right from the start. With this in view, we have conducted four Round Tables at Delhi, Bombay, Bangalore and Calcutta during the last one year as a prelude to the present National Seminar. Many industrialists and educationists participated in these discussions and the reports on these deliberations will be presented at the concluding session.

Several exercises have to be conducted before an educational system for future is evolved. First we have to forecast and identify the sociological scenarios at the turn of the century. It is projected by all agencies that by the end of this country we will be adding a second India to ourselves, even considering the success of the best family planning schemes. Due to this India will be facing glaring shortages in foodgrains, oil seeds, milk sugar, housing, textiles, energy, etc. Added to this, large scale industrialization will render the environment hostile for healthy living unless proper anti-pollution measures are taken. The picture therefore is staggering and the problem looks formidable. Is this picture inevitable? Can there be an alternative scenario which can be our preferred future? Is the country so helpless as to leave its future to the inexorable laws of history? While civilizations have dwindled and vanished in the past, should it happen now with the type of planetary civilization which is being evolved by humanity? No, this just cannot happen. Political will and social action will have to prevent this. Science and technology should be made to act as the material instruments of this journey into the future when we can say: Sarve Janah Sukhino Bhavantu.

What then are the technologies required to achieve this goal? Our solutions will have to be consistent with the fact that even in 2000 AD, 70% of our population will be residing in rural areas. Whatever we plan must be to raise their quality of life. The trend of migration to urban areas must be reversed.

If we want to take care of the millions of mouths and convert all hands into resources, the focus or aim should be to generate wealth with full employment, with an inherent system to avoid concentration of employment and wealth whatever may be the sector. Massive problems need innovative and sophisticated solutions. India has missed the industrial revolution. It should not miss the technological revolution. It has to leap forward into past industrial economy and accept and develop the best technology, whatever be its price, if it is socially relevant to Indian conditions. The words 'appropriate technology', 'rural technology', etc, should not limit us to low productive technology. All technology is appropriate if it solves the problems; that which does not solve is inappropriate. There is no rural technology, only that which solves the problems of rural people. Some rural problems require space age solutions. Thus we need a heirarchy of technologies from low to the most sophisticated. All this requires deliberation on the technologies for development of material goods, the training of the manpower at a rate that can match the industrial needs, the training of faculty to train these engineers, systems of education—both formal and nonformal—and several such issues. This Seminar is trying to provide a forum for such deliberations.

Any educational system anywhere in the world proved to be slow system which long reaction and response times. If we do not take the first step now or the right results in the future, we will lose the future. One should, however, bear in mind the progress cannot be a steep jump. It can at best be, along a steep curve. The process should recognize the past, consider the present and project into the future.

The future educational system should aim at social growth and individual spirituality. Technological skill enlivened and motivated by the all-transcending human spirit constitutes the human resource. The development of this should be the goal of the system. The task is to shape and harmonise material and spiritual, social and individual values for the making of a new society. In this the technologist with human values is a major participant. He must be trained to play his role. How do we do this? This is the subject of our discussions during the next few days of the National Seminar.

We hope we will be able to come up with some recommendations which can help planning of our education for future development.

Keynote Address by Sir Brian Flowers

Keynote Address by Dr A Bhattacharyya

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SESSION—I

NATIONAL SEMINAR

ON

EDUCATING THE ENGINEER OF THE FUTURE

BANGALORE, JANUARY 7-10, 1979

KEY NOTE ADDRESS BY SIR BRIAN FLOWERS

May I, first of all, thank you for your congratulations upon the new way in which I have to be addressed which I have not yet become accustomed. I am a physicist myself and am honoured to give this address to your Institution on which so much of the future of India depends.

I cannot speak of the present India let alone its future, the subject on which you are spending your time. But I am well aware, as a scientist myself, of the fine scientific traditions of this country and I am immensely impressed by the technological achievements that I have seen, especially the ones I saw at the atomic centre at Bombay.

I came to Bangalore unprepared to talk at this Conference and what I have to say will be very informal. Perhaps I can preface it by saying that if my words should be able to help you in the collosal problem that you have before you, as I can see by reading the Seminar documents, then I shall be exceedingly proud.

From the developmental aspect it is the process of industrial innovation that matters, that is, to say, it is not so much of the science itself but getting the results of science into industrial production to meet the needs of the ordinary people for goods and services appropriate to their circumstances. We are much worried about this in the U K too. We often hear people saying that though we are very good at science and we capture a lot of Noble Prizes but we seem to be not so good at getting the results of science into industry and getting richer by that. When I first came to India and had a talk in Delhi along exactly the same lines I asked "Where did you derive your system from" ? They all answered "From you". Then I said "We have the same problems too. You should not have copied us all so much" and our High Commissioner did not look at all pleased. Perhaps, I should start by playing with a myth that the problems in your country as well as in mine is that although science is a part of course of the innovative process but science as such does not create wealth - industry does. And Scientists themselves do not create wealth - engineers do. Thus the education of engineers is vitally important for all of us, for us as well as for you, according to different needs. But if educating the engineers for industry is what we are talking about rather than the education of an applied scientist for what some people call 'Engineering Science', then it is necessary that the total needs of the industrial process should be continuously remembered. There is a spectrum of activity which some people would say starts in a linear progression, but is not a linear programming and some kind of a cycle. This cycle sometimes

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starts with research and is carried on to more applied aspects which we usually call development and then on to product design, process design, and production itself involving such things as quality control, marketing, management at each stage of the cycle and, of course, feedback from every part of the cycle. I find it quite surprising that often professional engineers themselves seem to forget that they are part of the total process and seem to consider that the engineers job is design only. Engineers job is development and often they forget, just as scientists always do, that it is a part of a continuous process. It is necessary that even though most engineers inevitably specialise in some aspects of the process, some engineers should be encouraged to see the whole spectrum of industrial activity from the beginning of the formal training as engineers, so that they come to see the practice of their engineering speciality, whatever it may be, in the context of the total industrial activity. There has been over the last 10-15 years a great deal of discussion in the U K about the education of engineers and how it should be fitted into the total pattern of things. At one time I thought it consists of only talk and no action forever. But I am glad to say that the Government has now asked a few universities, of which Imperial College is one, to try to design courses with this total approach in mind. The best thing I can do today is to briefly describe the course that we have framed and are now beginning. I should, however, emphasise that this is only an experiment and like most experiments, it is liable to be changed in the course of being carried out. In about ten years time it may therefore look a bit different from what I am telling you now. You will also understand that at this point I can be extremely enthusiastic and convinced but later, when I have the experience of many engineers, the things may be a bit less optimistic.

At Imperial College we are trying to produce three streams of engineers who are very carefully selected and who will be encouraged to work together as much as possible on certain things while developing their specialities in the usual manner. There will be an entry each year of 20 mechanical engineers, 20 chemical engineers and 20 electrical engineers. This will be in addition to all the other mechanical, electrical, civil engineers, etc, that we accept for the usual type of courses. These additional streams represent a small proportion of the total engineering effort of Imperial College and a tiny proportion of the education of the country as a whole. We select these students according to the usual academic process of having examinations except that we set a very high level of entry academically. We select twice as many as we have room for and give to each student a list of industrial firms who have already agreed to take part in the operation of the course with us and have been selected by us for this purpose. These include some famous firms in the country. We give each selected student the list of these firms and tell them to go and get one of these firms to sponsor them. One of the firms will then sponsor the student financially as well as intellectually throughout his career with us in a very serious way. The industry will apply criteria different from us. They look for innovation, qualities of leadership and similar traits which they believe fit these youngmen and women for leading roles in industry in the years to come.

Having been selected in this way the students spend a preliminary year in industry before they come to us, and they go to the industry which has chosen them. Most of that year is spent working in the firm trying to see the total aspect of the industrial activity in a preliminary way. They get some glimpse of the totality of the industrial process. Since they have just left school they must not be allowed to forget how to learn some additional mathematics and some of the usual arts of engineering, machine drawing, etc, which are common to all engineers. Then they will spend a few weeks at Imperial College being introduced to the totality of what we should do for them in later years when they will be with us. After this preliminary year, they will come to Imperial College for four years. The basic engineering education in my country is an undergraduate degree leading to a Bachelors qualification which takes three years - and this is going to be four years. So, if we count the preliminary year, it is going to be 5 years, altogether.

During these four years, the student will take his engineering specialisation in electrical, mechanical or whatever his specialisation is. He will learn the basic things of industry in addition to engineering. He will learn something about industrial economics, industrial sociology, a European language (because we are conscious that in the future British engineers will be taking part with European engineers much more than what we have done in the past), some of the arts, management, how important it is to communicate with the people of other disciplines and people of the other languages, how to write well and speak well and present his arguments well in public and in a Board room. This is not just a set of management courses. At the end all this will be integreted into the four years course with some of the teaching done by the industrialists as well as by academicians. During the last two years there will be substantial industrial project preferably inter-disciplinary. It will certainly be industrially supervised. There will be two supervisors - one from the college and one from the industrial firm - and the students will be extended to take the total view of the total project. To introduce a small change in the process, they have to work out the economic significance which may perhaps change the employment pattern of the factory in which case they have to think about that. They have to think about how to sell to the managers the reliability of the change in the process in that way. That will be a part of their project.

Some of the academic work will be common to the three streams of engineering, especially at the beginning where basic disciplines like mathematics, material science and learning how to compute, economics, sociology and management sciences, will come together. At the end of the course the student will be able to talk about such things as the structure of industry and how the industrial structure matches up with the governmental structure of the country as a whole.

We are at the beginning and our first batch of students has been accepted. However, we have been running for some years now an earlier version, a pilot scheme, which has now produced three very encouraging annual outputs. We certainly have found how to work with firms and how to keep them with us and occupy and enthusiastically and ingenuously involved in the teaching process. But I do have some further grounds for optimism as well as that experience. First, the excellent students we have been able to attract this year for the new course. We have set a high academic standard but most of the students we selected have exceeded that. It is very encouraging indeed and we have been able to generate great industrial enthusiasm for what we are trying to do.

We hope that at the end we shall be able to give the student a triple certificate, the first part of the certificate will be usual BE degree. The second certificate will be from the firms which sponsored him. The third, which is very important and which has not yet been achieved although one or two of the Institutions are keen to do this, is that we hope that the professional engineering institutions of mechanical engineers, electrical engineers and chemical engineers will agree also to provide a certificate saying that taking into fact that student has pursued this particular course of studies at imperial college he will be excluded from the training requirements for the membership of the Institution. So the student by spending extra time on University education will not feel that he has lost out in gaining his professional qualifications which in the U K are extremely important to him.

We all hope that in addition to claiming proportion of our engineers in what seems to us to be more relevant that we shall also achieve very important objective of bringing together universities and industry through their joint responsibility for student selection and supervision of project. We believe that because this will mean man-to-man contact between the universities and the industry that we should be able to generate ideas that will go beyond the training of students and will involve contract work, research work on contact between the college and industrial firms who are collaborating with us.

Of course this will bring in extra money to the college but that is not the main reason for doing it. The main reason is that it makes the work we do immediately relevant to the industrial firms which is prepared to pay for it. We believe that the firm pays for the work that we do by way of research. I do not mean to imply that the work that the industry has not got sense to support is not all relevant. It may also turn up relevant in the end and very often will - but there are in this country other channels for finding the work of that sort.

May I then conclude this short and informal address by saying that this our experiment at imperial college is encouraging the process of innovations by providing for a small proportion of the best students available an opportunity to see their specialism in total context of industrial activity. People very often talk about the vertically oriented men, that is, some one who sees his subject in great depth but can do nothing beyond it. It is the way I suppose most of the students in the past have been brought up because our academies are like that. And then people sometimes talk about a horizontal man - a man who knows a little bit about everything but nothing much about anything. And we all try to avoid that situation but, nevertheless, if all of us work in a narrow specialism I cannot see the field as a whole and therefore unlikely to be able to communicate to those upon whom we rely if our work is to be of any use later on. And so, may I put before you the concept of a "T-shaped man" - the man who sees his subject in depth as a specialist but sees it in the context of a very broad spectrum of activity to which he will ultimately contribute.

SOCIO-ECONOMIC SCENARIO OF 2000 A.D. AND A TECHNO-FEASIBLE STRATEGY OF FUTURE

Dr A Bhattacharyya, FIE

FUTUROLOGY

The most important and pressing problem that faces mankind today is the achievement of peacefull and stabilized world with the growing population living in harmony with the environmental capabilities and resources. Early nineteenth century economist, T R Malthus predicted that un-checked population growth will increase in geometric ration while the needs and requirements, particularly fundamental needs for sustenence, will increase in an arithmatic ratio. Thus a crisis will engulf the very existence of mankind and a 'Doom's Day' was predicted. Possibly, the first futurologistic analysis was made through Malthusian prediction of population dynamics vis-a-vis food supply for future. Since then, the demographers, economists, geographers, technologists, scientists are at work to offset the so called 'Doom's Day' and to attempt harmonization of growing population with the increasing exploitation of resources, control on consumption activity compatible to future style of living for the future generation of population going through various transitional phases of social changes and technological growth. A new challenge has gradually emerged vis-a-vis the future of mankind particularly with respect to developing nations towards the following set of problems:

a. Growth and control of population in a given span of time;

b. Consumptional patterns of the people with particular regard to available material resources, hitherto known;

c. The mobility and dynamics of communities between urban centres and rural areas;

d. The expected aid and break-throughs in 'Technology' to resolve the imbalances that may arise in the process of transition through temporal horizon;

e. Changing scenario of socio-economic frame work in order that an appropriate mixed technology can be usefully evolved and the 'HIP' barrier can be overcome;

f. Harmonising the factors of space, energy and material resources with Eco-system.

Dr A Bhattacharyya, Past President, The Institution of Engineers (India), Director, IIT, Kanpur.

The transition from pre-industrial scenario must have a smooth transfer to post-industrial era with pre-designed social patterns compatible with scientific and technological capability over the temporal domain.

It must be clearly emphasized that India is a land of contrast where civilisations of several societal formats co-exist. To force this amalgam into the horizon of 2000 A.D. is itself a formidable task. Inspite of all the difficulties, there is no escape but to prepare the entire nation for 'Frontiers of Tomorrow' and the bibilical circumstances of 'Unto every human that hath shall be given and he shall have in abundance' be fulfilled. It must be clearly understood that such exercise is not only relevant but is in an essential ingredient in the planning models if the Doom's Day is to be by-passed.

The essence of Futurology is an interaction between the (a) supply and availability of resources, (b) needs, requireements and demands of coming generations and (c) exploitation; control and preservations, and often reinforcement, of the environment in order that the life style of the pople can be controlled consistent to the socio-economic scenario of the incoming century beyond 200 A.D.

Fig 1 shows the inter-play between supply, demand and eco-system comprising the essential components of Futurology.

The planning for growth and environmental quality is an essential exercise for designing the pattern of resources and ecological plans in a given social structure. The Development-Environment Nexus in the area of expanding social consciousness demand a number of irreversible policy decisions so that the socio-economic objects with respect to style of living and status of economy can be balanced with respect to resources hitherto known or are to be yet explored. The eco-system is to be balanced to check-mate environmental degradation. Thus futurologistic exploration for 'Technology' and 'Education' will require an extensive analysis having intensive interplay between the various levels of demands, supply and eco-requirements. The old concepts of growth economy are fast changing and a new international order in the economic and social science scenario is emerging. In Table 1 OECD has demonstrated that a large increase in gross national product for developing countries has taken place compared to that of developed countries inspite of huge flow of capital, abundance of high technology, and continuity of favourable trade in the developed nations. Because of high population density of developing countries, such growth does not give the necessary boost to push the socio-economic status of these countries towards the same level of economic order that exists in the developed countries today.

TABLE 1

WORLD'S ECONOMIC GROWTH
BETWEEN 1970 AND 1976

Gross National Product
in U S $(1976) in billions

	1970	1976	PERCENTAGE OF GROWTH BETWEEN 1970 & 1976
WORLD	5,490	6,970	26.9%
DEVELOPED COUNTRIES (NONCOMMUNIST)	3,450	4,180	21.1%
UNITED STATES	1,438.6	1,691.6	15.5%
COMMUNIST COUNTRIES	1,260	1,650	30.9%
DEVELOPING COUNTRIES	783	1,140	45.5%

Source: Organization for Economic Cooperation and Development.

The table above shows that the growth fate of developing countries was higher than that of developed countries between 1970 and 1976. However, the per capita growth rate of developing countries for the same period would be lower than that of developed countries, because of the higher population of the former.

(Source : 'SPAN' Jan. 1979)

Futuristic analysis may demonstrate that stablized societal power may switch towards the developing countries by realistic and appropriate measures undertaken either unilaterally or globally.

Fig 2 shows that time demain and time-rate of change are important parameters in the dilemma of conflicting planning parameters. The conditioning of environment systems by growth processes inducted through break-through of Science and Technology by gradual extension of resources in the shirnking space for growing population confronted with the problems of Pollution, Poverty, Imblance of Eco-system, Unemployment, may be able to tackle disparity of equi-distribution system patterns denying a dignified life style. It is essential to keep options open so that irreversible changes can be kept to bare minimum and a sustenance growth strategy can be devised by total planning of Nature by mankind. A simple heuristic analysis may not accure ecological consistence, economically sound and socially acceptable strategies forcing people to accept a developmental path having a demand structure and supply pattern which are incompatible with the eco-system. Besides the known material requirements towards the needs for bare survival, other needs such as Education, Socio-economic Equity, Political acceptability and Accessibility to cultural heritage should also be recognised. Several interfaces between the socio-economic planning with eco-system have got to be tackled by technological aids and broad-based educational programmes and demographic control.

This is why a systematic analysis which is economically sustainable and ecologically compatible should be undertaken and a definitive futuristic probe towards the scenario of 2000 A.D. is required to be made for ensuring an acceptable 'Life Sytle' of tomorrow.

METHODS OF ANALYSIS FOR PREDICTING FUTURE

Prediction of future is a very complex activity. The usual technique is to use the existing methods of forecasting for balancing demand and supply in the socio-economic scenario. All planning activities are bounded by such predictions whatever may be time horizon, a five year plan period or a twenty five years of prospective plans. The usual methods are: (a) Interdependent end-use methods (b) Independent assessment through surveys, (c) Regression analysis from time series data.

However, in the planning systems such projections are tested in the overall frame work of mixed economy through resource balances, material balances and on the assumption that the specific growth rate of the total economy towards future along with other parameters are related to growth.

Such kind of prognostics usually results in Expected Future where it is assumed that the environment will remain un-changed, historicity over time will continue in its trend, technology break-throughs will be scrace or incompatible, and existing life style will marginally change.

Alternative to expected future, there is a possibility of forecasting a Preferred Future. It will be assumed that time series incompatibility can be off-set by new technology in order to aid and conserve resources and materials. The education level and spread will be geared for adaptation of an improved Life Style. Thus new forms for future can be designed consistent to tomorrow's socio-economic scenario and technological status. Thus a Preferred Future can also be predicted.

Diagnosis, projection and prognosis leading to expected future can be re-routed to an alternative preferred future by technological intervention and by developing strateties by which the socio-economic scenario of 2000 A.D. can be visualized.

Nodoubt, there will be multitude of alternatives amongst which an optimal one towards balanced growth can be identified. Fig 4 shows the strategy towards futurologistic development processes for any country particularly so far developing countries having mixed economy like India.

The central focus in the entire futurologistic analysis is Population. Development, industrialisation, improved style of living, changing pattern of livelihood are all dependent on the size of population as well as the smallest pupulation unit such as the family size. Very often the positive effect of development are overpowered by the swelling of population. It is important of understand that all the aspects that are being considered relevant in the prognosis for 2000 A.D. are centered around population. The Club of Rome predicted a pessimistic future when confronted with the gingatic nature of problems faced through population explosion.

Around 1976 mankind crossed 4 billion mark. If the exponential rate is admitted with excess of births over deaths the catastrophy as predicted by Malthus may arise. The alternative future is also discussed by leading economists like Leontief. According to them, after reaching certain level of living standard and a degree of urbanisation, the growth of population may start decelerating. According to Leontief, by 2000 A.D., a population of 8 billion may be reached and then onwards a slackening may arise reaching a total world population of about 15 billions around 2075 A.D. The Indian scenario is shown in Fig 5. By 2000 A. D., it is expected that the Indian population will reach an expected figure of about 960 million from the present day 650 million mark. The urban rural composition will change from 130:520 to 290:670 and thus creating a number of new problems demanding flood, housing, energy and various other auxillary resources for sustenence at the planned style of living. This forecasting has been made by extending the present population rise-trend. However, if effective control can be exercised on population growth both under the old as well as under the new circumstances the figure can be brought down to a preferred population size of around 850 million against the expected future of 960 million of people.

LIFE STYLE OF 2000 A.D.

The quality of life and the necessities of living around 2000 A.D. will depend on the size of population, family structure, resources available, pollution problems, energy requirement and similar other factors.

There are many methodologies by which the approach towards the life style of 2000 A.D. can be ascertained. One such approach is the concept of acquiring and maintaining high GNP. If a reasonable high GNP or rate of growth can be maintained the quality of life tenable in future can be predicted. However, the use of GNP as an indicator has not been found to be an acceptable index for indicating the improvement of style of living of the people as a whole. The GNP can be a good indicator as a measure of productivity but may not be relevant when the well being of the people at large is concerned. A high GNP may not indicate the mortality rate or the number of people living below the poverty life, or the literacy level etc.

The PQLI (Physical Quality of Life Index) suggested by the Overseas Development Council of U.S.A. gives a scale which has also several draw backs. PQLI includes:

(a) Infant mortality,(b) Life expectancy,(d) Literacy level.

All the above parameters are socially relevant but do not have economic bearings. PQLI for India is 40, while for Sweeden or U.S.A. and U.K., PQLI values are close to 100. The absence or non-inclusion of economic parameters may show that some of the developing countries having the same GNP as the developed countries may have PQLI index well below. The Association for Application for Science to Human Affairs (ASHA) has developed a development index termed ADI. All the indexes are shown in Fig 6 in a comparative form:

LIFE STYLE
AND
QUALITY OF LIFE INDEXES

1. $\boxed{\text{G.N.P.}} \Longrightarrow \left\{ \Sigma \left[\text{goods + services} \right]_{\text{Cost}} \right\} + \left[\text{Net foreign income} \right]$

2. $\boxed{\text{NATIONAL INCOME}} \Longrightarrow \left\{ \left[\text{G.N.P.} \right] - \left\{ \text{Capital consumption} \right] \right\}$

3. $\boxed{\text{Q.O.L.}} \Longrightarrow \dfrac{\boxed{R} \times \boxed{TL} \times \boxed{\eta}}{\boxed{P^n}}$

[V K GAUR]

4. $\boxed{\text{A.D.I}} \Longrightarrow \dfrac{\boxed{GR} \times \boxed{J} \times \boxed{E} \times \boxed{L}}{\boxed{BR} \times \boxed{IM}}$

GR = Growth rate
J = Employment
E = Literacy
L = Life expectancy
BR = Birth rate
IM = Infant mortality

[ASHA]

5. $\boxed{\text{PHYSICAL INDEXES}} \Longrightarrow$

(a) No. of Cars/1000 people
(b) Kw / Capita
(c) No. of M/C Tools/1000 people
(d) No.of Telephones/1000 people
(e) % Population below poverty line
(f) Per capita income per annum

Figure 6

According to ADI the information can be classified into four groups:

(a) Low income group with an average ADI of 43,
(b) Middle income group with an average ADI of 341,
(c) Upper income group with an average ADI of 594,
(d) High income group with an average ADI of 10470.

If the Preferred Future of Life Style compatible to an ADI 2023 is to be attained by 2000 A.D. by India the following parameters must be met with:

GNP = 3.5%
Employment = 850 per 1000
Literacy = 850 per 1000
Birth rate = 25 per 1000
Infant mortality = 50 per 1000
Life expectancy = 70 years

None of these parameters are very high. GNP is modest, full employment has not been achieved, spread of literacy remains incomplete. Inspite of these modest goals, the condition of life style compatible to 2023 ADI from a living of life style of 43 ADI demands massive efforts and a great boost in the form of total application of Science and Technology is needed. It must be appreciated at this point that if ADI governs the preferred life style rather than the massive growth of GNP through large scale industrialisation and massive energy consumption etc. the planning must become compatible to ensure resource balancing and basic well being of people simultanoously aiming at improved life style of living.

Another measure was given by Shri V K Gaur where the Quality of Life has been defined as a basic function of resources, technology innovations and sociao-economic system efficiency and inversely dependent on the size of population. This factor (QOL) makes a direct attempt to couple the life style with population, resources and technological break-throughs. Increase of population and a desired quality of life will need fulfilment of a set of basic needs and primary requirments. All the primary, basic or tertiary needs (tangible and intangible) are shown in Fig 7.

BASIC HUMAN NEEDS	
. PRIMARY →	FOOD WATER CLOTHING HOUSING
. BASIC SERVICES →	EDUCATION ENERGY MEDICARE HABITAT TRANSPORT COMMUNICATIONS
. FUNDAMENTAL RIGHTS →	EMPLOYMENT (PRODUCTIVE) EQUITY JUSTICE FREEDOM LEISURE
. DERIVED NEEDS →	INFRASTRUCTURE . PHYSICAL . HUMAN . TECHNICAL . INSTITUTIONAL
. SOCIO-POLITICAL GOALS →	PARTICIPATORY DECISIONS MASS-BASED DECISIONS CONTROL AND MONITORING POLITICAL SYSTEMS

Figure 7

The above mentioned needs for increased population of 2000 A.D. will have to be met which is itself a gigantic task. A few aspects of the scenario in the essential and basic areas will be depicted here in order to expose the formidability of task ahead which although difficult but still can be surmounted by designing appropriate alternative futures through application of Science and Technology, of course coupled with Socio-Political will.

Futuristic forecasting particularly in technology and engineering sectors can be further classified into commodities which can be different than those have been presented in the Basic Human Needs table. The recognised planning sectors include:

(a) Basic commodities
(b) Intermediate commodities
(c) Capital goods and durable consumer commodities
(d) Consumer goods.

Basic commodities are these items which directly enter into production or manufacture of other products or indirectly as a material resource such as steel in the metal based industries, aluminium or copper in the non-ferrous group of industries, sulphuric acid in chemical industry and so on. Theintermediate commodities are these that enter into other industries after undergoing considerable processing such as springs, belts, nuts, paints and varnishes etc. The capital goods are of durable nature and enter the consumer environment and play an important role in developing the capacity for feeding the industrial sector. Consumer goods are produced by the aid of capital sector and are directly going to the consumer market. The interlinkages between these are shown in Fig 8.

While the primary data for food, housing, garments etc are basic needs under consumer goods sector. Production of these are often dependent on the output of the capital goods sector and control the consumer output capacity. The basic informations regarding the demand and supply of all commodities are to be carefully collected and processed by eliminating conflicting informations and by making compatibility analysis in order to ensure the correct technique for futurelogistic projection for a given time domain transitional changes at intermediate temporal nodes.

NEEDS IN THE CONTEXT OF 2000 AD SCENARIO

The needs and requirements of basic and primary sector can be estimated by 2 different modalities (a) through the projection of expected future scenario and (b) by developing some normative measures for depicting a preferred future scenario.

A few important sectors in the socio-economic scenario which are essentially dependent on the technological break throughs and engineering initiative are outlined below:

Food

The crisis in the food front is inter-woven with the growth of population on one hand and the adoption of technological measures along with enforcement of technological considerations of cultiveable land with planned programmes for appropriate crop rotation in order to meet the needs of 2000 AD. In 1971-72 India produced about 105 million tonnes of food grains of all types. Fruits and vegetables account for about 20 million tonnes, milk production about 2400 million tonnes, while the production of meat, poultry meat, eggs and fish etc are estimated to be 518, 69, 78 and 746 thousand tonnes respectively.

Assuming the following norms per capita:-

(a) 100 grams of milk per capita per day,

(b) 30 grams of meat/fish per capita per day,

(c) 30 grams eggs per capita per day.

The requirement of 2000 A.D. will be 88.4 million tonnes of milk, 2.3 million tonnes meat, 275 thousand tonnes of poulty meat, 10.6 million tonnes of eggs, 8 million tonnes of fish. However, allowances are to be made for wastage, post-harvest losses and extra requirement for anual workers etc. It is immediately revealed that a big break-through is required to boost the productivity which has got to be changed by 2000 A.D. to a considerable extent. If the cultivable area remains static at the same level then the yield per hectare will have tobe substantially raised by 2000 A.D. The rice production should be around 2050 kg per hectare, wheat 2473 kg per hectare, maize 1559 kg per hectare, etc. Such kind of yields are possible only by Technology Adaptation which will enable multiple cropping in order that the population of 2000 A.D. could be provided with food with permissible nuitritional value. There are number of inter-connected problems which will have to be solved which include:-

(a) Improvement of irrigation,

(b) Improvement in handling and storage,

(c) Improved food processing,

(d) Increased production of Fertilizers, Pesticides etc.

(e) Scientific techniques for fishery and hatchery

Besides, attempts should also be made to look for new horizons in the area of food resources such as unicellular algae, development of synthetic foods and use of waste re-cycling for food etc. All these are dependent on initiative and innovation of engineers and technologists during the period between today and 2000 A.D.

WATER RESOURCES

Till recently, water resources in India have been considered as a resource in abundance. Recent studies have revealed that with the increased requirements of water both for the urban and rural sectors pollution-free water is fast becoming a scarce commodity. It is important that spatial and temporal imbalances between the supply and demand of water resources are bridged before the advent of 2000 A.D. A quick look at the water-use statistics will reveal that, at the current rate of growth, industrial water usage will rise from 18.89 billion litres per day in 1978-79 to about 152 billion litres per day by 2000 A.D. In the domestic sector, assuming that 70 percent of villages and 95% of the urban population are served with organised water supply at the normative levels of 60 litres per capita per day in the rural sector and an average of 145 litres per capita per day in the urban sector, water usuage will rise from 24.98 billion litres per day of 1968-69 level to about 85 billion litres per day by 2000 A.D. However, a lot of approximations are involved in this estimate. The withdrawal pattern envisaged in 2000 A.D. is not a very significant percentage of water potential of the country. However, pollution is the biggest hazard in the coming century particularly in view of high temperature and low levels of summer flows in India.

Not only a total water management plan has to be evolved but strict control ever pollution problems have got to be exercised so that the water does not become the real problem inspite of existence of high potential. Agricultural water demand will rise extensively from the level of 1600 billion litres in 1978-79 per day to about 3600 billion litres per day in 2000 A.D. The total water withdrawal from intra-basin and inter-basin resources will rise from 1718 billion litres per day in 1978-79 to 4093 billion litres per day in 2000 A.D.

Such tremendous water usuage expansion will need massive engineering input in all sectors of water usages as well as strict pollution control so that the eco-system is properly protected while fulfilling the 2000 A.D. needs.

Housing

The preferred family size may decrease from 5.7 in 1971 to 4.5 in 2000 A.D. It is also expected that per capita income will rise to Rs. 2500/- at present price level by 2000 A.D. Further three mega-metropolitan cities, five metropolitan areas, 1900 towns with population of 100,000 each, will be created by the mobility of people from rural to urban areas. The population density in the urban area will become 250 per hectare while in the rural settlement 75 per hectare by 2000 A.D.

Between 1971 and 2000 A.D. house-holds are expected to increase to 125 million, thus giving a new dimension during this period to the housing needs. This in turn will need a huge expansion in the production of building material. Only demand for bricks in the year 2000 A.D. may become 162 billion and and 8-fold increase in timber use may arise. Such a tremenduous expansion will need a big technological infrastructure, appropriate land use policy, as well as a full-scale squatter settlement in transforming the slums. The realistic and expected housing units may be about 80 millions units thus leaving a very large gap between preferred future need and the need that can be realised. Only a very large effort towards the moderanisation in techniques for development of building materials and successful search for new resources can tackle the housing problem.

ENERGY

Requirement for energy for 960 million people to live in the preferred life-style with a reasonable growth of income will depend on the availability of energy. Any increase in productivity through development of machineries will need energy. Every sector, whether agricultural or industrial, rural or urban, will demand a satisfactory level of energy consumption. It has already been demonstrated that energy consumption per capita per annum. In the United States of America 4274 dollors is the per capita income per annum while the energy consumption per capita per annum is 11,128 kg of coal equivalent in 1971. Comparable figure for India is 86 dollars per annum and 189 kg of coal equivalent. It can easily be seen that energy has already been a big bottle-neck even in today's scenario with large scale expansion of population this will be further aggravated.

To project the energy scenario of 2000 A.D., let the energy base is taken as 200 kWh per year per house-hold with 95% of rural house-holds electrified and 25 million agricultural pump sets are energized, the requirement will change from 128 billion kWh in 1978-79 A.D. to 700 billion kWh in 2000 A.D.

The coal requirements will rise to about 216 billion tonnes. It is important that the mix of power production between hydal, nuclear and thermal power generation will reach the targets of 25 000 MW nuclear power to supplement 77 000 MW thermal plants and 60,000 MW of Hydel generation in 2000 A.D.

Even this estimate will be so high that it will be necessary that the new energy sources like solar energy, magneto-hydrodynamics generation and wind power will have to be harnessed. With the aid of new technologies, it will be possible to reach the target level of 2000 A.D.

TRANSPORT

In the area of trasport a big break-through will be needed as the mobility of the people will continue to increase along with the increase of population. The rural traffic will increase by 2.5 times for carrying of freight compared to the existing level, and by 3.5 times for paggener carrying compared to the existing level. In the same period the road traffic will increase by 4 times for carrying the freight and 8 times for carrying passengers. Air traffic will increase by 16 times for freight and 24 times for passenger compared to existing levels. The inland water system will increase by almost 100 times and pipeline carrying of freight will increase by 5.5 times. This immediately brings us to the gingatic nature of problem in the connectivity of nodal points, balancing between various modes of transport and a development of new road net work so that 75 percent of the total population can use motorable roads.

The use of bullock carts will be limited to 10-15 percent of total population traffic within a radius of 8-10 kms. It will be necessary to increase the route length of road from existing 12 lakhs km to 40 lakh km and the surfaced road length should be about 60 percent. In the railway sector, to speed up the traffic and match the density, it will be necessary to add additional 10,000 km and to convert another 10 thousand km from meter gauge to broad gauge tracks. Another 7000 km of broad gauge tracks will be needed so that the 2000 A.D. nodal points can be opened up. Such gigantic transportation design will need a kind to total transport management and engineering achievements of highest order in order to build the infrastructure for the intervening period between now and 2000 A.D.

FINAL SCENARIO

The final check on demands, both for expected or preferred life style, will be quite staggering. It must be understood that throughout the history of mankind, inspite of rise and fall of many civilisations, mankind has survived and met many challenges. The scenario though not projected in details is quite formidable for adaptation of technological skill, political will and social aims and certainly will make dent into future life-style. Indian engineering must prepare itself right from now to meet the challenges of 2000 A.D.

EDUCATION

Generation of suitable man power and appropriate education by 2000 A.D., man will prove himself to be different from 1900 A.D. In 1900 A.D., man used to look at the moon and devise fantacies but before the end of the century, man landed in the moon and took a look at our beloved planet which appeared so serene and beautiful from the space far beyord. All these achievements have been possible because of his ability to achieve break through in engineering and technology and usage of science with technology. The level of nature of education for 2000 A.D. will have to be compatible with social demands, technological scenario evolved in the intervening period, and the educational pattern by which informations are compressed into knowledge. The level of life style and national prosperity will eventally depend on the achievements of technologists, scientists and engineers. They will be the principal agents for modernising the nation's effort towards development. Therefore, the education, and the technical education in particular, must play the role of the major instrument for change. The change will be there, and our planetary civilisation will have to meet the challenge of this change. Let the journey to the future of 2000 A.D. be crowned with triumphant success.

References:

1. Murthy, P N. 'Educating the Engineers of the Future' published by the Institution of Engineers, Basic Document.

2. Parikh Kirit 'Energy', published by Macmillion Co. India.

3. Chaturvedi, M.C. 'WATER', published by Macmillion Co. India.

4. Sheth, S.C. 'Outlook for India's Future', published by NCST.

5. Amla, B.L. 'Study of Energy Scenario 2000 A.D.'

6. Chatterjee, S.P. 'Population Dynamics', Paper presented at the seminar on Population Crisis, Jadavpur University.

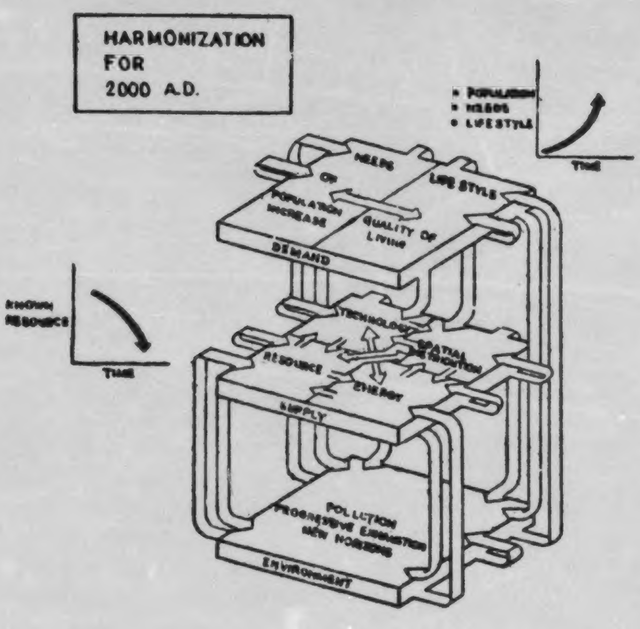
7. Ghosh, A.P. 'Methods of Projection for Industrial Development in India'. UNIDO paper No, ID/WG-160-6 July, 1973.

8. Maudgal, S. Report on 'Housing', published by NCST.

9. NCST Panel on Futurology 'The basic document on Futurology', published by NCST.

10. Gaur, B K 'Village India in 2000 A.D. - Dream and Reality', paper presented at NCST Seminar.

11. Sach, I. 'Hormanization Game', Mazinger, Vol. III/IV 1977.


HARMONIZATION
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SPATIAL
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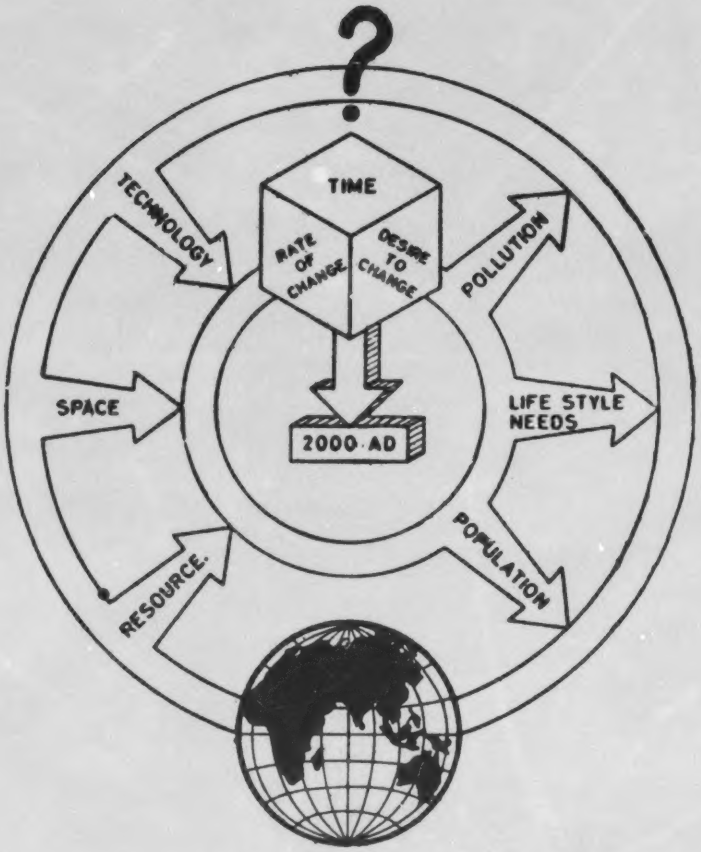
ENERGY
SUPPLY
POLLUTION
PROGRESSIVE EXHAUSTION
NEW HORIZONS
ENVIRONMENT

[Adapted/modified from I.Sachs
Mazingira 3/4, The harmonization game]

Fig. 1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2000 AD
TECHNOLOGY
SPACE
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POLLUTION
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POPULATION

Fig. 2

PROGNOSTICATION TO 'EXPECTED' FUTURE
OR
NORMATIVE CONTROL TO 'PREFERRED' FUTURE ?

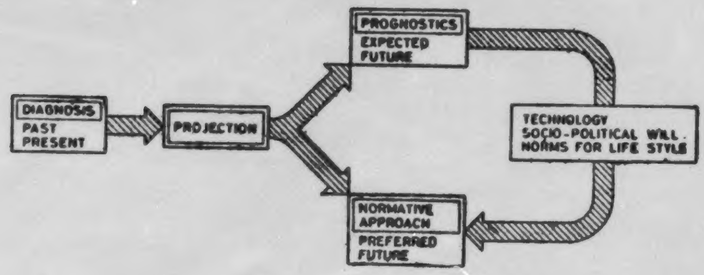
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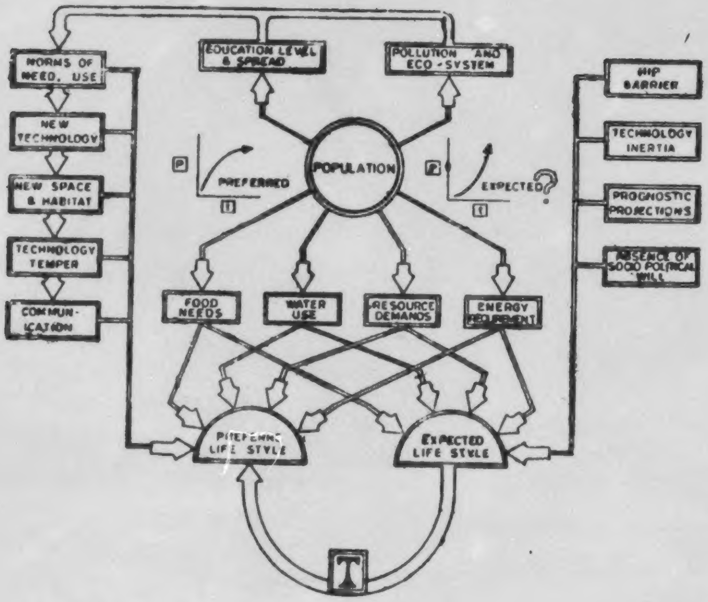
Fig. 3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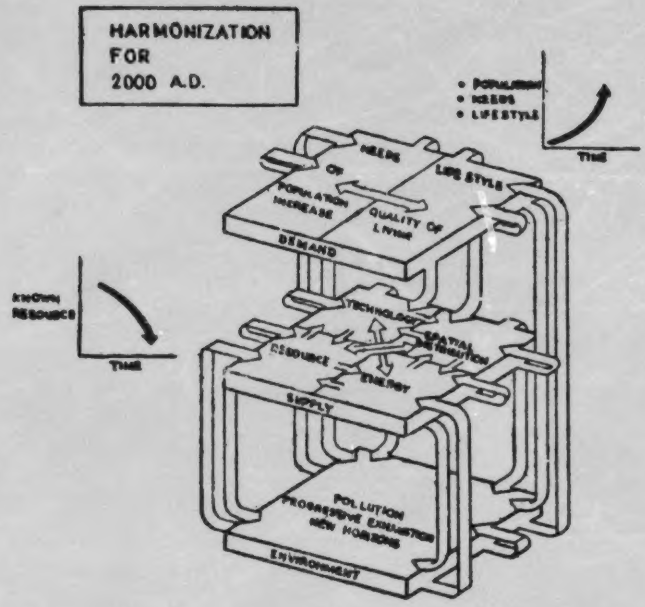
POPULATION THE PRINCIPAL CONTROL FACTOR

Fig. 4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[Adapted/modified from I.Sachs
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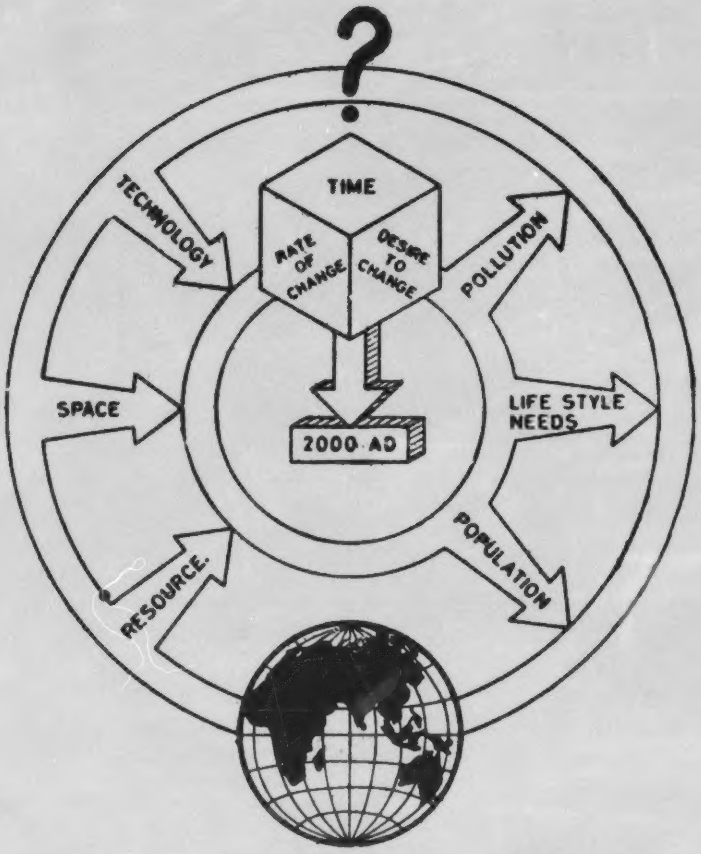
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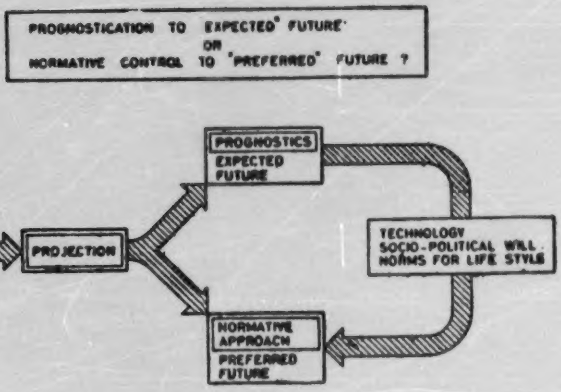
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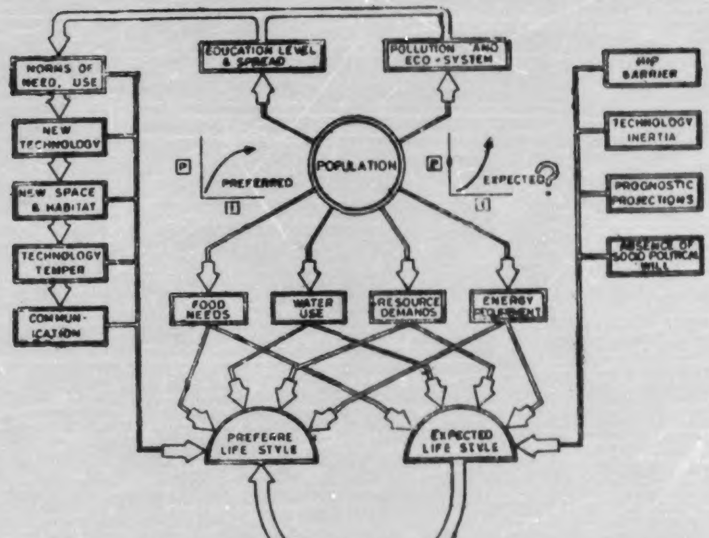
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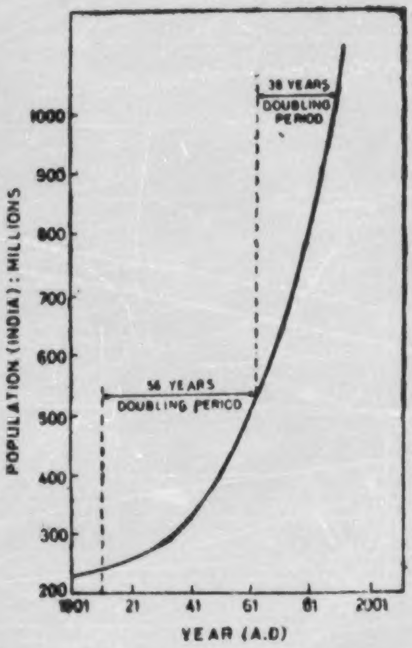
POPULATION THE PRINCIPAL CONTROL FACTOR

Fig. 4



[Source: Ncst Base Document on Futurology]

Fig. 5

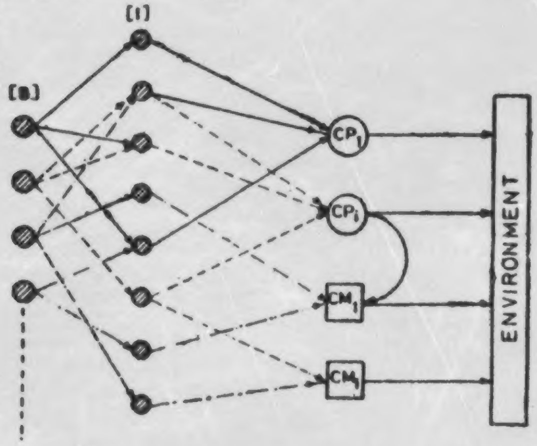
COMMODITY CLASSIFICATION

BASIC COMMODITIES [B]

INTERMEDIATE COMMODITIES [I]

CAPITAL GOODS AND DURABLE CONSUMER GOODS [CP]

CONSUMER GOODS [CM]



[I]
[B]
CP_1
CP_i
CM_1
CM_i
ENVIRONMENT

Fig. 6

SESSION—2

NATIONAL SEMINAR
ON
EDUCATING THE ENGINEER OF THE FUTURE
BANGALORE, JANUARY 7-10, 1979

Keynote Address by Dr S C Seth

Keynote Address by Shri F C Kohli

Address by Mr J G Watson

SOCIAL AND TECHNOLOGICAL SCENARIOS

Dr S C Seth *

The future consists of two kinds of events. Events we would like to see happen such as, 100% literacy, 100% employment and events which we would not like to see happen such as mass unemployment, famine, war, etc.

India today lives in the state of agraria, industria, as well as post-industria, at the same time. If we want to move into 21st century with confidence and strength, it is important that we shape our engineer's education as early as possible. This change should come in the following directions:

EDUCATIONAL REFORM

Since the knowledge levels are changing swiftly, technologies are quickly becoming obsolescent, we need to overhaul the educational content of our engineering syllabus at all levels.

In this regard the following points pertaining to Education for & towards future are worthy of consideration:

1. Strengthen, widen and deepen a system of non-formal education and with appropriate opening and entry into the formal system,
2. Develop closer coordination between educational planning and man-power requirements,
3. Work education should be a part of the curriculum.
4. Intake in institutions of higher education should be related to man power forecast, if necessary opening a few colleges should be stopped with a generous provision of freeships and scholarships for weaker sections.
5. The curricula should be geared to training for self-employment.
6. 'Cafeteria' system of education where one has a greater freedom in choosing areas of one's interest and time schedules that do not require

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* Member-Secretary, Futurology Panel, Dept of Science & Technology, Government of India.

rigid sequential stages of school and college attendance with fixed hours in the day time for 'acquiring' knowledge.

7. Flexible syllabus and course content to ensure greater creativity and less curricula burden on the pupils,

8. Assessment to be made in terms of performance credits and not necessarily written examinations,

9. Degrees to be valid over a limited time-frame. To overcome knowledge obsolescence degrees shall have to be 'renewed'.

10. Mode of education: "Study-work-study" in all fields with increased emphasis on 'creativity' at all levels,

11. Certification will go and a new education system will be evolved in the learning system. This evaluation will include people trained not only in the formal and the non-formal systems but also these who have achieved excellence else where in the society, including the traditional avenues in skills and knowledge and semi-professional competence outside both formal and non-formal systems,

12. Facilities for continuing education and improvement of skills should be provided for all, whether they have learnt in formal institutions or otherwise. Practical training in vocational and professional education will be provided through in-service placement ie, in workshops, factories, etc (wherever work is done).

13. At the top level of the research and learning, evaluation will for different skills be arranged by their peers such as Royal Academy of Arts, Institution of Engineers (India), Institute of Chartered Accountants, College of Surgeons, etc.

14. Technical education to have a much larger 'practical' component,

15. Industry to be called upon to bear a share of the cost of technical education since they are the biggest beneficiaries of the products of technical education,

16. Delinking of degree requirements from jobs and linking jobs to work experience and work credits.

ANTICIPATORY TRAINING

It is necessary that we should give our engineers training in Technology forecasting, Technology assessment, and Social forecasting.

SOCIAL COMMITMENTS

Engineers should have more social commitments because of acute poverty condition that prevails in the country. This can help abolish poverty conditions to some extent.

CREATIVITY

Engineers should be innovative, creative and should pursue all such things that ushers social, technological and developmental change. We need not carry past into future.

NON-FORMAL SYSTEM OF EDUCATION: PERMIT LATERAL ENTRY INTO FORMAL SYSTEM

Education should not become an instrument to promote social inequality. It is important that craftsman, technician be allowed to enter the formal educational system through lateral entry.

CONTINUOUSLY UP-DATE KNOWLEDGE

We must embrace talent wherever it is available in society outside formal educational set-up and help induct them into the formal educational system. Else, we shall carry second rate citizens into 21st century.

The Engineer of the future will have several career in a life time. This requires continuous training and updating of knowledge.

DEGREES SHOULD BE VALID FOR A SHORT PERIOD

The time has come when the degree should be valid only for short period and should be got revalidated after a dose of updated, new, knowledge.

For this purpose, organisations like the Institution of Engineers (India) in conjunction with the Indian University and Technical Institutional net-work have a great role to play.

The author concluded by saying that a great future awaits us if we can turn our vast population into a resource - as they are, where they are.

We should understand the logic on growth of direction of technology. We should choose technology wisely with an eye in future. We should make quantum jump into some areas of sophisticated technology so that we can help satisfy the basic minimum needs of the large human system which India is and shall become so even much more by the years, 2000 A.D. when our population would have doubled up.

Every engineer should understand the imperatives of future, learn anticipatory process and crisis management.

The future engineers will not only be a technologist he will have to be a forward looking and efficient manager.

Since "Future is Today", our managers should perfect the current day decision-making process by accommodating all conceivable and possible analysis of future. This pertains to human needs, training, education, technology and management systems.

TECHNOLOGY FORECASTING - TECHNOLOGIES 2000

F C Kohli *

Technology Forecasting (TF) is no longer a crystal-ball gazing. It is a discipline that has come of age. It is a systematic attempt in gaining understanding of the consequences that may arise in the future from the present developments and choices or for that matter the choices that we may make or technologies that we may develop in time to come. It has become a useful and meaningful tool and has gained a measure of respectability.

It is relatively a new tool of analysis and is of considerable value in policy planning. TF is a prerequisite for determining of Appropriate Technology alternatives and Technology Assessment of these alternatives.

Technology forecasting basically involves identifying,

a. What is possible,
b. What is probable,
c. What is preferable.

It relates work of technologists with those of economists, social and political scientists. It may start from the societal needs or requirements and determine the technologies or development of new technologies that would be required to meet those needs. It is "many to many" coupling exercise, as it requires assessment of not only technological situations but also of socio-economic situations in addition.

TF is the perception and interpretation of change. Today's accelerating pace of product innovation is the result of expansion of technological developments. Technology causes changes in products, production processes and input resources including the human resources.

It is often possible to forecast technology change as though technology would follow a historical trend. It could be extrapolation of functional or technical capabilities. For example, if we take some attribute like speed over time or lumens of light over time, it is possible to arrive at reasonable estimate of the future possibility. TF will also involve, apart from estimating the future value of the attribute, assessing the effort involved in changing the attribute and time required to change it. It is an exercise in searching the data that is available and subjecting the data to extrapolation

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* Tata Consultancy Services, Bombay.

and correlation analysis to establish the future. This type of TF is called Exploratory TF. It is quantitative and relies more on techniques like Trend Exploration, Envelope curves, Probabilistic Forecasting, Analogy Curves, Network Analysis, Decision Trees, Morphological Analysis and Models.

It starts from state of technology at present and defines a sequence of future activities which will lead to future value of technical attribute. It assumes that technological progress will continue in the current state and non-technical environment will not materially change. However, it does include finding the effects of technology on non-technical environment. It requires frequent updating and reacting to situations involving environmental changes by promptly changing or modifying the forecasts.

On the other end of forecasting spectrum is the Normative TF. In this, start is made by identifying and listing future social goals and needs, national objectives, missions and tasks. Then assessing the relevance, sufficiency, limitations, and cost effectiveness of existing technologies; and finally determining new areas of research in science and technology required to meet the goals. Normative forecasting is generally subjective and lays much more emphasis on non-technical environment. It is also active in posture but more complex. The tools that are available are Scenarios Writing, Consensus methods like Delphi and Brainstorming, Cross impact analysis. Input/Output Analysis, Simulation etc.

For the most applications, TF is a combination of Exploratory and Normative methodologies.

TF is gaining in acceptance as a management and planning tool as it,

- adds perception and interpretation of change,
- provides insights into structuring and various approaches,
- assesses impact of new technology identifying new and appropriate areas of research and further study,
- stimulates generation of ideas,
- provides an objective and factual assessment of economic benefits (direct & indirect) of R&D investments.

Methods like Delphi and Scenario Writing depend on the competency of participating experts and skills of the administrator. Apart from these other important inputs are availability of input data; continuing sensitivity to external conditions and availability of technical expertise of high order. In any TF exercise it is of advantage to have intelligent and creative individuals on the team. Creative persons sometimes prophecy technology developments decades in advance.

Herman Oberth described rocket travel between planets in 1920 and Arthur Clarke in the issue of Wireless World, October 1945, forecast communication satellites. Major technologies have three stages -

- when you do what you used to do, only do it better, more effectively - Technology switch-over,
- when you do new things that you never did before - Technology transfer,
- when it results in change in the life pattern of the society - Mature Technology.

Technology Switch-over is replacement of old technology by newer one to solve similar problems or accomplishing similar objectives - such as replacement of piston type of engine by a turbo jet engine. Technology Transfer is application of technology in an area other than one for which the technology was developed or to which it was first applied, such as use of transistors earlier and now micro processors in protective relays in power systems.

I would like to look at the status of the supporting technologies in power systems and computers around the year 2000.

A power system is part of energy system **with a** larger and more complex system and which in turn **is a part** of socio-techno-economic system which defines the overall energy needs of the society. Primary objective of the power industry is to plan, organise, construct and operate power system that provides electrical energy that is reliable, economic and does no harm to the environment. Some of the assumptions regarding power system development are -

- a growth rate of 10% per annum means doubling every seven years. It takes almost 6 to 7 years to plan, construct and commission a power plant. It, therefore, follows that at any given time, the capacity in planning stage should be equal to what is already installed and in operation.

- Based on a known and viable technology, a new product takes about 10 years to develop and another 10 years to commercially manufacture, supply and instal. Equipment now in research stage, for which economic and technical breakthroughs are still required, will require another 10/15 years before becoming commercially viable. Such technologies are MHD, Fusion Reactors, superconducting cables, cryogenic cooling of the rotating equipment, solid state circuit breakers, equipment for voltages above 1100 KV.

- Cost reduction is the last stage of any new development and this factor extends the life of the technology.

- Electrical Equipment usually have a life of 20/40 years - this means that equipment now under planning will be still in operation in 2000.

EQUIPMENT TECHNOLOGY

Generating Units

Today there are 1100 MW, 1800 rpm turbine generators in USA, two units of 1500 MVA rating in West Germany. In the year 2000, unit rating will move to 1000 to 2000 MW with average around 1250 MW. No spectacular increase in rating is expected as economies from size increase for higher rating units are marginal. Most of the units will have both rotor and stator water cooled. A few units may have super conducting rotors with cryogenic cooling. All units will have static excitation employing solid state devices.

Hydro generating unit sizes may move upto 700/800 MW. Hydro units of low rating for utilising units with relatively low cost for utilising the low head sites in canals and river systems would be developed and become available. Research in 'Stratflo' type hydraulic turbine indicate possibility of achieving substantially low costs.

NUCLEAR FISION

Gas cooled fast breeder reactor, and liquid metal (sodium) cooled fast breeder reactor are under test. Both these should be in commercial service on a large scale within 10 years.

FUSION

Construction of Tokamak fusion test reactor, a devise based on magnetic confinement of plasma, is under erection at Princeton. Work is also under way to determine the optimum approach for building an economical and reliable fusion device based on the use of accelerators that focus many beams on a centrally located fuel pellet.

REPLENISHABLE SOURCES OF ENERGY

In addition to Hydro, another 15/20% energy would come from replenishable sources such as solar, biogas, straw & agricultural wastes, garbage and refuse, etc.

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SOLAR ENERGY

A photovoltic cell with 25 KW peak power is in service to provide power to an irrigation pump. Its efficiency is about 5.5%. Solar cells would towards the year 2000 have efficiency of 25%. The solar cells would become cost effective by 1985. Solar plants will supply about 10% of energy requirements in 2000. Their size will be between 50,000 to 150,000 KW. Solar generation plants will become cost competitive with nuclear plants and some fossil fuel plants some time between 1990 and 1995.

BIOGAS

Most of the rural areas in this country would generate and use biogas to meet their energy requirements. Technolgy would favour the centrally located large sized plants rather than the Khadi Bhandar type available at present.

STRAW & AGRICULTURAL WASTES

One tonne of food grain is accompanied by 1-2 tonnes of straw. Dry straw has a calorific value half that of coal. A small portion of straw is consumed as fodder and remaining burnt or destroyed. Straw may find its way in the waste-heat boilers as fuel. Considerable research in methods of collection and design of steam generators is required. Perhaps some prototype plants would become available towards the end of the century.

GARBAGE AND REFUSE

Large metropolitan areas generate considerable garbage and waste. Cities spend large sums on collection and disposal. The garbage in most of the cities would be burnt as fuel in specially designed and installed waste-heat boilers in another 10/15 years. In some cities, energy thus generated may amount to 15 to 20% of the cities' requirement.

WASTE HEAT RECYCLING

Only about 30-35% of the fuel heat value gets transformed in the conventional fossil fuel plants. Most of the plants now under planning would be a combined cycle of gas and steam turbines achieving total utilisation of about 40 to 45% of heat value.

ENERGY STORAGE

Considerable research is in progress on Sodium Sulphur and Zinc Chlorine Batteries. Batteries with storage capacity 50 to 100 MW hr would become available.

COAL GASIFICATION

A test facility for converting 5 tonne of coal into gas of low calorific value is in operation. Potentially significant gain in overall efficiency can be accomplished by employing both steam and gas turbines based on the use of coal gasifier. The gas is physically cleaned and fired in a gas turbine combustor. The gas discharged by the gas turbine is used in a steam generator which supplies steam to the steam turbine.

TRANSMISSION

By 2000 DC transmission voltage with ± 1000 KV with capability to transmit 4000 MW would be in operation. DC conversion equipment would be all solid state. DC breaker should become available. Many DC circuits would operate in parallel with AC circuits thereby increasing the system stability. New insulator technologies will permit higher voltages on existing narrow right of ways. Porcelain as an insulator will be replaced by polymer silicon material insulators. These will have superior dielectric and mechanical strengths.

SWITCHGEAR

Future substations upto and including 765 KV will use gas insulated switchgear using SF6. Such switchgear will be compact, provide improved safety, reduction of fire and explosion hazards, reduced noise emission and radio interference.

POWER SYSTEM CONTROL

Assumptions:

- Plant capital costs and fuel costs will continue to rise rapidly, which will justify the expenditure of more and more money to improve the economics of power system operations.

- Advanced types of central station generation, storage and transmission and distribution systems will be installed. Environmental right of way and siting concerns will require higher level of performance from the installed facilities. Thus, future control systems will be called upon to handle more complex problems under increasingly stringent and demanding conditions.

- Self generation at the customer end as a part of the process recovery and solar generation will place entirely new demands on the controls.

- Introduction of solar and wind generation, wet or dry cooling of condenser water at thermal and nuclear plants; air and thermal pollution etc will greatly increase weather dependence. Very sophisticated system for monitoring the weather and the environment will be integrated into future control systems along with models for forecasting weather and environmental impacts.

- Future control systems will make extensive use of data-network communications and microcomputer technology.

The implications of the above are that future control systems will be based on extensive and complex models, involve many sensors and computers all interconnected through extensive data networks. It is also clear that there will be a heirarchy of control levels defined by strategy at each level. The elements at the lowest level (Level 0) will be direct acting devices for automatic local control - relays, governors, regulators, combustion controls, thermostats, etc. These will depend on the sensor signals. Almost all the logic at this level will be microcomputers. Sensors will give digital outputs and actuators would accept digital inputs.

At the next level (Level 1) will be the controls at the Control Room. Control functions will be implemented by the operators assisted by the digital computers. Instruments will have digital and graphic displays. At the next higher level (Level II) controls will be at local and state load despatch centres. At the apex, controls will be at the regional and national coordination centres. Controls at these levels will be for information processing and for supporting the decision making. During the normal conditions, digital computers will make decisions and cause direct implementation with the operators supervising and making risk-tradeoff decisions. When the system is in trouble, the equipment in danger will be removed automatically and computers will indicate to the operator alternate possible actions and their implications. Control rooms will be equipped with large wall size displays driven by the digital computers.

The vast amount of digital communication will be carried through a variety of channels. In some locations, optical fibers will be used. Message flow will require considerable control logic. Extensive use will be made of mathematical models, look-up tables, supplemented by equations so that models complement each other.

Power system operation training will be entirely handled on simulators driven by the digital computers.

COMPUTERS

Continued miniaturisation of processors, hardening of software and reduction of computing costs are the anticipated features. In USA, the 1980's will be the era of maturity when industry and technology begin to stabilise, despite continuing rapid growth. The use of computer and microcomputers will become widespread in home, automobile and educational applications. In the nineties, every aspect of individuals' life will interface with computers in one or another way. American homes should by then contain 20 or more microprocessors.

The technology trends that are apparent are -

a. Convergence of semiconductor and computer technologies in the areas of logic design and memory devices,

b. Impact of microprocessors as a separate entity and as a design component in mainframes,

c. New architecture in which memory modules become more important than computational modules,

d. Design and development of software including hard software,

e. Data communication techniques and future technology.

Large scale and very large scale integration of logic circuits is making extremely powerful mainframes available in small packages. Bits per chip and logic circuits per chip would be many times of what they are today. The bubble memory would replace discs and tapes by the nineties. CPUS would use cryogenically cooled Josephson-function devices. Solid state travelling wave amplifiers will find use. IC functional densities would come down to line widths of 0,1 micron or less.

FIBRE OPTICS

Fibre optics in computers will bring significant advantages of wide band width, no electronic interference, low loss and electronic isolation.

LARGE CAPACITY FIXED DISKS

Increased capacity more than 10,000 bits/inch and about 800 tracks-per-inch. Such drives would accommodate in excess of one billion characters per drive.

Non-Impact printers, laser printer for high speed printing and magnetic ink jet printer for slow printers are already available. Considerable improvement in speed, quality of printing and price should materialise during the decade.

Technology trends are leading to very small, low cost, stand alone microcomputers and to both large and small distributed processing networks. Computing, processing and storage power will be dispersed to better meet the needs of the users. The problems in the future will not be technological but government regulations on privacy, social concerns and personal needs.

A major consideration in the future will be the cost of software. In future, canned programs will evolve into hard software. That is, programs will be replaced by dedicated microcomputer type hardware. Hard programs chips will be sold through catalogues. With hard programs, the need for programmers at the user site would be drastically reduced. Most of the future machines will have the capability to emulate a variety of different computer architectures.

Like the programming, the computer maintenance may see drastic future changes. Maintenance now runs to 30% or more of computer system operating costs. In the future, with the fault tolerant system modules, this figure may come to only a few percent.

EDUCATING ENGINEER OF FUTURE

J G Watson*

LEARNED SOCIETY

The founders of the Institution of Civil Engineers in 1818 stated only one object and this embodied in the Royal Charter of 3 June 1828, the sesquicentenary of which we recently celebrated, has been the main object since, namely, "the General Advancement of Mechanical Science and the acquisition of that species of knowledge which constitutes the profession of a civil engineer".

The interpretation of this object was that the Institution should, through meetings and the reading and discussion of original papers submitted by the members, promote the propagation of knowledge to the members.

It was to be expected that an Institution for the advancement of knowledge would in due course wish to measure the effectiveness of its propagation of knowledge and take an interest in the standard of knowledge acquired by its members. Only those who were capable of absorbing and applying the knowledge they were exposed to should be admitted to corporate membership and contribute to the further development of the profession.

When he became the first President in 1820 Thomas Telford reminded those present at his inaugural address that:

> 'In foreign countries similar establishments are instituted by Governments and their members and proceedings are under its control but here a different course being adopted, it becomes incumbent on each individual member to feel that the very existence and prosperity of the Institution depends in no small degree on his personal conduct and exertion and by merely mentioning the circumstances will, I am convinced be sufficient to commend the best efforts of the present and future members; always keeping in mind that talents and respectability are preferable to numbers and that from too easy and promiscuous admission, unavoidable and not infrequently incurable inconveniences perplex most societies.'

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* Secretary, The Institution of Civil Engineers, London.

THE QUALIFYING BODY

By restricting membership to those who reached certain minima of qualifications and by the encouragement of its members to obtain and maintain those qualifications the learned society evolved into the qualifying society which is the second and perhaps the most important aim of the Institution.

In 1922 when the role of qualifying body for all civil engineers was conferred on the Institution by its Supplemental Royal Charter, the Institution's 104 years of history stood it in good stead.

It was in the public interest that the Institution be given its new powers and to enable the general public to distinguish readily those who are properly qualified that the designation MICE and the title Chartered civil engineer were granted.

Since 1922 periodic reassessments of the requirements for the education, training and experience of the civil engineer have taken place in the UK. Education and Training was under review in 1931-34 and again in 1942, 1951 and 1958.

Important conferences organised by the Institution were held at Imperial College London in 1964, in 1968 at Queen Elizabeth College London and in 1972 at Glasgow. As a result of changes foreshadowed in these last three conferences, a Committee was set up in 1973 to examine the needs of the civil engineer of the future: it became known as the Chilver Committee.

TECHNOLOGICAL DEVELOPMENT

The civil engineer has a vital role to play in the development of any country. The structure of any country, whether described as developing or developed is not static, and the more highly developed it is, the more sophisticated is its technology and its mode of development.

The fuel that fires development is wealth, and wealth has to be created. Manufacturing industry is the prime creator of wealth and this involves primarily Mechanical, Electrical, Production and Process engineers who create capital products and consumer durable goods which raise the standard of living.

Not all are directly engaged in wealth creation, many are concerned with consumer products,*∠agriculture and service industries; for example, water and electricity supplies; they contribute an essential element also.

*∠ for example,

But the precursor of all this is the civil engineering which is the infrastructure of the country upon which all else is built. The factories, the houses, the roads and railways, the docks and harbours and the airports.

The reservoirs and wells, the waste processing plants and the water conservation schemes. Each of these branches of engineering requires a species of specialist but overall there must be the broadly educated, widely trained and soundly experienced professional engineer.

This has been the fundamental policy of the Institution of Civil Engineers for more than a century.

THE GENERAL PRACTITIONER

In his Presidential address to the Institution of Civil Engineers on 9 January 1866 Sir John Fowler stated:

> 'Although it has become the practice in modern times for many Civil Engineers to be employed chiefly, or almost entirely in some one branch of the profession, I desire to repeat my conviction that it is most important that the early preparation and subsequent study should be as extensive as possible and should embrace every branch of professional practice, not only for the purpose of securing to a young engineer more numerous opportunities for his advancement but also because sound knowledge and experience in all branches of engineering will greatly add to his efficiency and value in any special branch.'

The education of the Engineer of the Future must not lose sight of this fundamental principle that the Professional Engineer must be the man of vision, of creativity, of innovation with the knowledge, practice and experience to bring his plans to pass for the public good.

He must be supported by a structure of Technician Engineers, Engineering Technicians and Craftsmen, each in his own specialism performing an essential function to contribute to the whole.

I am confining my further remarks to the Professional Engineer at the apex of the pyramid. What are the requirements for this Engineer of the Future ?

CHILVER COMMITTEE

This was the question the Committee was set up to consider in February 1973. It followed a series of Conferences at which there had been much talk but little follow-up action. The 1973 Committee was asked to bring together the conclusions of those Conferences and to seek further evidence. This Committee under Dr (now Sir Henry) Chilver, Vice-Chancellor Cranfield College of Technology, completed its investigations and reported to the Council of the Institution in January 1975. With little alteration its recommendations were adopted at Council meetings in July and December 1976 and they are being implemented.

The Chilver Committee stated that those who enter the civil engineering profession should have received a broader secondary education than is generally appreciated by educationalists in the UK. First degree studies at Universities and Polytechnics should also be broader though there is need to maintain the appropriate depth of study in a limited number of relevant subjects. It recommended that the Institution should exercise more control over all first degree courses which should be reviewed and approved by the Institution at regular intervals.

Substantial changes were recommended at the level of practical training. All graduates should undergo basic practical training on programmes 'approved' by the Institution. The assessment of the graduates' basic education and practical training should be more continuous, more thorough and more searching than the present system, the 'Professional Interview'.

The basic education and practical training of about seven years, from entry to a first degree course and leading to admission by a first professional examination to a proposed new grade of Associate Member, should be the foundation of the civil engineer's professional career.

Professional competence can only be developed and identified after becoming an Associate Member and a professional competence assessment must be made at a stage about three years after admission to the grade of Associate Member. Success at this second professional examination will admit to corporate membership and the designation 'MICE'.

ACADEMIC QUALIFICATION

By adopting the recommendations of the Chilver Committee, the ICE is committed to requiring evidence of greater breadth in the early education of candidates for the profession. To the Moderation of University/Polytechnic first degrees in relevant subjects at regular intervals in collaboration with the Colleges themselves. The main purpose of the first degree courses is to provide a student with a basis for scientific thinking and for continuing learning of scientific principles and their application to creative engineering achievement.

PRACTICAL TRAINING

One of the most important areas of study of the Chilver Committee was that of the practical training of the graduate. A number of deficiencies of the present system of practical training were evident.

Many graduates preparing for professional careers followed largely unstructured practical training programmes. This resulted in delay in qualifying at the Professional Interview which benefits neither graduate nor employer.

The Committee envisaged that all graduates, on approved training programmes would be supervised by 'Supervising Civil Engineers' who would be registered with the Institution and re-registered every five years. Their responsibilities would be clearly defined.

Throughout the training and post training experience period up to the second Professional Examination, there would be periodic reports of progress sent to the Institution by the graduate's Supervising engineer and by Interviewers arranged by the Institution. The graduate himself would also report on the contents and benefits of his training. At present it is theoretically and, to an increasing extent practically, possible for a graduate civil engineer to qualify for corporate membership at the age of 25 years.

The Committee concluded that the professional competence of a civil engineer cannot be assessed properly at that age; it is only possible, in practice, to assess his professional competence in his later 20s or even later still. Civil Engineers should not be admitted to corporate membership of the Institution until their professional competence has been assessed and judged satisfactory.

FURTHER EDUCATION

Education and Training does not stop at entry to corporate membership. There is a need for continuing education - keeping up with new developments through in-career training at all stages of a civil engineer's career.

The Institution should be able to give advice to members about courses and for this purpose the ICE has appointed an "Engineer Adviser" - a full-time officer who will also serve the Further Education Board set up to ensure the Institution provides an efficient advisory service on in-career training which will benefit all members of the Institution.

CONCLUSION

The field of civil engineering has always been one of changing needs for education and training. In such a situation there is always a danger of education and training becoming outmoded as the field develops. There is also a need to monitor the planned changes over the coming years and to keep the education and training of the Engineer of the Future under continuous review.

The needs of one country may not match the needs of another. We speak of 'appropriate technology', that is, the need to recognise and match the technology to the state of development of a country, its social as well as its technological climate. The Professional engineer, the broadly education, widely trained and soundly experienced creator, innovator, is not needed in large numbers but in high quality.

The standards of the ICE are high because membership is world-wide. Not all who practice civil engineering may or need to hold such standards, but we must all be pointing in the same direction although we may be at different milestones along the road.

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Keynote Address by Dr H R Arikere

Address by Prof N S Ramaswamy

FOOD NEEDS, SUPPLY POSSIBILITIES AND PRODUCTION TECHNOLOGIES IN 2000 A.D.

Dr H R Arikere *

Man has always been conscious of the fact that food is one of his basic daily needs and he has to struggle for obtaining the same. He has always therefore been anxious about its steady supply. Even when the population was less than 10 million in the period prior to agriculture 10,000 years ago, nightmare of hunger haunted him. It was, however, the pronouncement of Malthus in the year 1798, that population would always increase to the limit of food supplies, that drew the attention of the world to the likely catastrophe of starvation as a result of unlimited increase in population. Though the food production capacity has increased tremendously in the course of time, the problem of providing food to everyone, atleast at the minimum level required for normal growth and activity is continuing to haunt the world.

Few problems have been more anxiously and widely debated than that of providing food to all. The problem aroused world wide interest during 1970s when the world food reserves slumped due to poor harvests as a result of widespread droughts in many parts of the world. Two World Conferences have been held so far in this decade. The first was in 1974 arranged at Rome by the Food and Agriculture Organisation at the level of Governments. The second was the one organised by the World Food Institute of Iowa University in Ames, Iowa, USA in 1976 and the theme of which was "Role of Professional in Feeding Mankind". The deliberations of these two Conferences and many others have clearly brought out that the key question is whether the developing countries as a group can produce an additional 500 to 600 million tonnes of cereals over and above their current production level of about 400 million tonnes by the turn of the century. As an answer to this question, two distinct lines of arguments have been presented. The pessimists emphasise the unfavourable factors and prophecise mass starvation within this generation itself. Optimists argue that the mass starvation can be avoided if the food problem is tackled resolutely both at national and international levels.

It is said that there is no shortage of physical resources of land and water for several decades to grow more food. However rosy the picture presented by optimists may look, it is clear that the resources are not unlimited and therefore the rate of population increase should be drastically reduced. However effective the implementation of the

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stringent measures proposed by different countries may prove, it is almost certain that the population will be more than 6 billion by the turn of the century and enough food to feed this population must be produced and distributed to avert mass starvation. In fact, it is felt that even reduction in population increase is closely linked to abundance of food supply. It has been stated that the food problem of the next 25 years is essentially manageable, but it would require tremendous national and international efforts. It has also been stated that all the three aspects - increased production, improved distribution and lowering rate of population growth, are interrelated and must be pursued simultaneously. If the present trends as obtained in the last 20 years continue with regard to population and food production increase, one estimate indicates that the food gap of developing countries will increase to 85 million tonnes by 1985 itself. Another estimate of the maximum food production potential of the world from a technical feasibility point of view shows that agriculture could produce approximately thirty times the present food quantity under favourable conditions of optimal farm management applying all the technology known at present.

FOOD NEEDS

The quantity and kind of food consumed varies considerably from country to country and from region to region within the country and also from individual to individual. The dietary habits are largely dominated by local availability of food materials. It is interesting to note that man's capacity to go without food and his ability to eat food are both limited. The average intake as obtaining in different countries is given in Table 1. While the intake of 1500 calories a day is considered a starvation diet, an intake of 3000 calories is generally believed to be too much. This indicates that the well-fed man can eat only twice as much as the one on starvation diet. The present food consumption pattern, however, is much different. The per capita annual consumption of people living in poor countries is, on an average, less than one-fifth tonne. While consumption in moderately affluent countries like those in Europe is as much as half-a-tonne, it is more than a tonne in highly affluent countries of North America (Fig 1). The quantity of grains consumed directly varies considerably depending upon the level of affluence. Therefore, there are two factors responsible for global demand for grains - increasing population and rising incomes. At present, in poorer countries the former dominates and in others the latter. Taking into consideration the probable increase in population and incomes in different countries, the world demand for cereals is likely to be more than double the present levels as can be seen from Table 2. It is of interest to note at this stage, that although the demand in 2000 A.D. is expected to be as it is indicated here, the theoretical demand if worked out at the minimum required level, that is, at about one-fifth tonne per head per annum, it will be just about the same as the quantity produced at present, that is, about 1200 million tonnes.

Food has to satisfy not only the energy needs but also protein, mineral and vitamin requirements. It has been shown that unbalanced intake of protein and carbohydrates and fats, especially at early stages of growth gives rise to malnutrition and may cause harmful and almost irreparable after-effects on health. Such malnutrition is observed to specially occur in vulnerable groups like children, nursing mothers and pregnant women. It is a redeemable observation in that if calorie intake is taken care of by raising cereals consumption, it would be possible to meet the protein needs. Estimates of per capita calorie and protein demands in the world are given in Table 3. It may be seen that the rate of increase in demand on proteinous foods in developing countries will be more than in the developed countries.

Dietary habits vary considerably from area to area and are dominated to a great extent on the local availability of foods. The diets which are evolved by experience through a process of trial and error through ages are by and large adequate to maintain normal health. Extensive surveys have been conducted by various agencies like the Indian Council of Medical Research, State Governments and National Sample Survey Units to know the existing pattern of diets in different parts of the country. The average intake of nutrients in different States in India as revealed by these surveys are given in Table 4. It may be seen that the intake of cereals and protein is fairly adequate, but there is not much of variety. Diet of mixed cereals and pulses is considered nutritionally superior. Intake of other groups of foods especially of vegetables, fruits, milk and animal foods is observed to be below the levels recommended. Based on the mean calorie intake by each group the cereal requirements in 1973 as worked out by the National Commission on Agriculture was 75.85 million tonnes. The requirement on the basis of improved diets is stated to be 88.8 million tonnes. The calculations further indicate that the requirement including seed, feed and wastage of usual 12½ per cent works out to 90.3 million tonnes, which is just 3.2 million tonnes short of production. If the quantity of sweet potato, potato and tapioca is added, this gap is also covered. It is observed that though the situation, on an average, may not appear that alarming, the dietary pattern of special groups like workers required to put in heavy manual labour, tribal people and vulnerable groups like school children, nursing and pregnant women is far from satisfactory.

The production mix will have to ensure the supply of pulses, oilseeds, leafy vegetables and fruits, in addition to cereals, to provide for protein, calories, vitamins and minerals. Further, it is only when the nutritional leakages are minimised by controlling infection, effective immunisation and other health care programmes that benefits of adequate nutrition can accrue to the consumers. As stated earlier, the demands depend upon the population as well as income increase. The demographers have estimated that the polulation may reach the level anywhere from 830 million on the lowest side to 1032 million on the highest side depending upon the extent to which the population control measures are successfully implemented. The required allowances will have to be made for the possibility of increased demands based on the level of affluence. Taking all these factors like nutritional standards, population increase, the demands of various food items as worked out by the National Commission on Agriculture are as given in Table 5.

SUPPLY POSSIBILITIES

It is clear from what is presented so far that the global needs will be more or less double the present level of production. Theoretically, the quantity that is produced at present would be more than sufficient even in 2000 A.D. if arrangements could be made to distribute it equitably at the rate of about one-fifth tonne per head per annum, which is considered to be the minimum required for sustenance and normal activities. But can this be done ? The answer is naturally in the negative and therefore the realistic needs will be double the quantities produced at present. Possibilities of achieving the levels of production to meet the needs will have to be considered by all concerned. The possibilities have been examined critically at various levels and by various agencies all over the world. There is an agreement on the point that by using the available resources of the world, it should be possible to feed the humanity at more than adequate standards. Only half of the available land fit for cultivation is being utilised at present. It is generally agreed that the land available for food production in the world is about 2.8 billion ha. out of which 1.4 billion ha. is presently put to use. In many parts of the world, the existing land can be put to better use and also under multiple and mixed cropping. Water resources are still to be fully exploited. Almost half of the cultivated area can be provided with irrigation support. Water use efficiency can be improved further with the available knowledge. Productivity is very low in many developing countries. The level can be increased manifold by using available technology. After critical analysis of the prevailing situation, the World Food Conference held in Rome adopted the following resolution which was endorsed by the United Nations in December 1974.

> "Every man, woman and child has the inalienable right to be free from hunger and malnutrition in order to develop fully and maintain their physical and mental faculties. Society today already possesses sufficient resources, organisational ability, and technology and hence the competence to achieve this objective".

The World Food Conference also recommended establishment of various institutions like the World Food Council, Committee on World Food Security and other measures to ensure action at global level to meet the challenge of providing food for all. These institutions have been established and some are making progress. This shows that there is earnestness to solve the problem at global level and similar earnestness is still to filter down to the levels of all countries in general and those countries which have been listed as "most seriously affected" as India in particular. It is only then that the solution to the problem can be expected.

The results of analyses carried out by the National Commission on Agriculture indicate similar or even better possibilities as far as the problem of feeding a massive Indian population of about a billion people by the end of the century. The requirements to feed such a population has been indicated earlier. The supply probabilities as against the domestic demand as indicated by the National Commission on Agriculture are given in Table 6.

It is seen that the country would be able to meet the demand even on the assumption of high income growth and the possible export demand in respect of the basic food articles. Even in the case of fruits and vegetables the supply possibilities are bright. The realisation of production potentials, however, depend on the extent to which agriculture will be serviced in regard to the technology transfer, building up the infrastructure needed to arrange for the production and distribution of needed inputs and for processing, transport, storage and marketing of the farm products.

Even though the land resources are limited, the present land use pattern and efficiency cannot be said to be as it should be. About 45 per cent of the net area of the 328 million ha geographical area of the country is sown to various crops every year. Forests occupy 22% of the land. Of the remaining 33%, 15% is uncultivable waste land, 11% is under permanent pasture and miscellaneous tree crops and 7% remains fallow for various reasons. While the contribution towards GNP from arable area is as high as 47% and 1.5% from the forests, it is almost nil from the remaining 33%. At present, not only the yield levels of various cultivated crops are low, but the uncultivated land is most inefficiently used. There is considerable scope to bring about improvements in the productivity by putting every hectare of land in every region under the crop best suited to it. It is surprisingly true that in vast areas there is misfit in the rhythm of the crop grown and the soil moisture supply. As a result, yields are low. Just by adjusting cropping patterns so as to get maximum benefit from every hectare of land cultivated, there is considerable scope for increasing the production. Similarly, there is scope for increasing the net returns from forest areas and from the cultivable fallows as well as permanent pastures and also from uncultivable wastes by reclaiming the same. The uncultivated areas can be used for producing forage material to support animal husbandry activities and various kinds of tree crops to augment the supply of fodder, fuel and timber. Since the climatic conditions are favourable, practically all over the country, throughout the year, vast areas can be double or triple cropped with appropriate irrigation support. Fragmentation and sub-division of holdings are causing considerable hindrance to scientific land development and exploitation and utilisation of water resources. The situation can be remedied to a very great extent by bringing about land consolidation and thus improve the land structure as has been done in many parts of the world and in some States in India like Punjab and Haryana. Thus the available land resources can be stretched to a considerable extent.

Water resources of the country are much better as compared to many other countries. The rainfall received over 75% of the area is more than 10 cm per month for at least 3 months. This magnitude and spread is sufficient to raise at least one crop successfully in a year. The spread as well as amounts are much more than the minimum required for raising one crop while it is possible to take even two crops with judicious management of water received through rain, by adopting better water harvesting, storage and utilisation techniques than the ones adopted at present. It is only 25 percent of the area where scarcity conditions are likely to occur more often and therefore, the need for protective irrigation is imperative.

Out of the 400 MhaM of rainwater that is received annually about 105 MhaM can be harnessed. At present, the area irrigated is about 40 Mha. It should be possible to bring an additional area of another 40 Mha by 2000 A.D. by harnessing some more usable water. Thus, the total gross irrigated area can be increased to 80 Mha. If this harnessed water is used with care and efficiency through proper land development, multiple cropping and improved agronomic and water application techniques, the benefit from irrigation can be extended to larger areas and thus help stabilising production.

Natural and artificial water sources like ocean, seas, lakes, rivers, reservoirs and tanks are yet to be exploited to the fullest extent. Indian ocean is the least exploited among oceans. The unexploited but exploitable potential of other water sources is vast. They yield rich and good proteinaceous material. Utilising all these land and water resources for increasing the production of plant and animal products, the country can increase the food production to the extent needed. As envisaged by the National Commission on Agriculture the land and water use pattern would be as given in Tables 7 & 8.

The country has abundant human resource in terms of number. Properly developed and utilised, it can be a asset instead of liability. The peasantry which has strong commonsense and native intelligence though illiterate is a great asset to the country. During the last few years, it has been shown that the farmers of the country have the capacity to perform if they are shown convincingly that the new techniques are economically sound and provided with wherewithals to put the technology made known to them, into practice. It is for us to develop and utilise the human resource to the advantage of the country as a whole. It must be said that making a living from farming is not easy. It is an art requiring to be practised and learnt; it is a complex applied science needing the knowledge of principles of a large number of sciences; and finally it has to be ventured on business lines with the full knowledge of the intricacies of application of economic principles. There is a tendency all over the world to run away from farming for various counts. It is in the interest of the country to see that the farmers continue to remain in the business of farming by providing all the attractions and support needed to encourage them to do so. On the contrary, in India the feeling is that the farmers are the most harrased and neglected lot. If it continues to be so, the peasantry of the country may be destroyed and it may never be possible to revive it as Oliver Goldsmith said, "Bold peasantry, the country's pride when once destroyed, can never be supplied".

INPUTS AND PRODUCTION TECHNOLOGIES

With the background provided so far of the land, water and human resources of the country and how these resources could be utilised to provide what is needed in the form of food articles, I now proceed to place before you some technological aspects and the tasks required to be performed as far as supply and services are concerned to boost agricultural production at the rate needed to meet the demands by the turn of the century.

It has been shown all over the world that agricultural production could be increased provided the technical knowhow is made available to farmers along with the inputs required for adopting improved practices. Important inputs are seed, fertilisers, chemicals and machinery. Importance of good seed is known to farmers and they are prepared to pay for tested and certified good seed. But the organisations required to produce and market such a seed are still to be built up. To ensure adequate supply of good seed, to cover at least 80% of the cultivated area, seed production will have to be organized on 2.5 Mha as against few thousand ha at present. The produce which is likely to be 2.5 million tonnes will have to be processed, stored, transported and distributed as and when required by farmers tilling the land around 6 lakh villages in the country. It is not a small task. It is estimated that 30,000 distribution centres will have to be organised in the country. The greatest benefit that would accrue from this venture is that of opening up of employment opportunities to millions of men and women in rural areas and to a large number of trained technologists and technicians.

Equally gigantic is the task connected with production and supply of fertilisers, agricultural chemicals and machines, implements and tools. The consumption level of fertilisers which is as low as 20 kg/ha at present will have to be increased to 80 kg/ha. Even the consumption will be quite low as compared to the level of 391 kg/ha in Japan and 308 kg/ha in the Netherlands. By 2000 A.D. the consumption of fertilisers in the world is likely to be much more than 100 Million tons as against the consumption of 16 million tonne in India. In addition the local manurial resources like farmyard manure, compost, green manure and city waste will have to be mobilised to the maximum extent involving again a large number of men and women in the process. Use of chemicals to control pests and diseases is minimal at present. It can be said that the use has just started. The present level of use which is just 30,000 tonnes of various chemicals has to be increased manifold, but after taking all the care and steps necessary to minimise pullution hazards.

Farm power is another input which is not considered adequate. At present though on an average the power availability is 0.35 hp/ha, it is just 0.1 to 0.2 hp/ha in many parts of the country. The studies in the world have shown that the optimum rate of power input is about 0.8 hp/ha. The National Commission on Agriculture has recommeded increase of power input through machines, especially for developing and utilising water resources (50-55 M.hp) and for land development and heavy tillage (18-20 M.hp). The need for producing improved implements and tools is imminent. In short, selective mechanisation has to be the approach not only with a view to improving the efficiency of farm operations but also reducing the drudgery of farming population especially of women workers. The total power availability is required to be of the order of 130 M.hp and 0.86 hp/ha as against 50 M.hp and 0.35 hp/ha respectively in 1971.

What has been stated so far with regard to input supply is more applicable to crop production activities. Food production is not just field crops production. These statements, however, apply well to fruit and vegetable crop production and also to a very great extent to other activities connected with production of other food articles like meat, milk, eggs and fish. The support needed for animal production activities include production and supply of feed, drugs and veterinary services and equipment needed for handling the products etc. Similar needs exist for carrying on fish production activities too. In all these sectors there is scope for increasing employment opportunities to a great extent. The list of inputs needed is large and it is neither necessary nor feasible to elaborate the same on this occasion. In short, it can be said that supply and services functions as related to activities connected with production of all food articles will have to be systematically planned and implemented to ensure availability of needed inputs to put the new technology in each sector of activity into practice in order to ensure that every producer derives benefit for himself and at the same time helps the nation as a whole.

At this juncture, it must also be said that the infrastructure built so far to carry on the activities at post-harvest stage of processing, storage, transport and marketing are probably sufficient to meet the needs of deficit economy. The country cannot continue to survive all the time with hand-to-mouth economy or deficit economy as has been the case for many years. There is an urgent need to revamp and strengthen the structure to meet the challenges of surplus economy. The challenges of surplus economy have come to the surface on number of occasions during the last decade of green revolution which should be taken note of and action taken to resolve the problems.

The question that is very often raised is whether the country has made necessary advances in regard to developing and making available the appropriate technology to enable development and utilisation of available resources and to put costly inputs that are proposed to be produced and made available for use. Agricultural research has a long history in the country. The institutions which were set up from the beginning to middle of this century have been suitably reorganised and manned by well trained personnel to discharge increasing responsibilities as far as developing new technology is concerned. There is, however, need for continuous vigil in the matter of upgrading, expanding and reorganising to make them function more effectively. New innovations which will go

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a long way in improving the productivity per unit area and per unit of various inputs are continuously becoming available as a result of intensive research going on all over the world in general and in India in particular. The mechanism for transfer of technology, however, is still required to be strengthened qualitatively and quantitatively to ensure quick adoption of new technology by large number of farmers. In short, steps needed to ensure increased production and equitable distribution are :

(1) identifying and solving of technological problems as and when they arise by strengthening the research base

(2) reaching millions of farmers with new innovations and solutions to problems that arise in adopting new innovations through strong extension service

(3) ensuring production and supply of quality inputs and removal of bottlenecks that might arise at post-harvest stage by building up appropriate infrastructure

(4) keeping a vigil on proper distribution and utilisation of wealth generated by increased production

(5) avoiding complacency at any stage and giving proper direction at appropriate time.

It is said that the proof of pudding lies in its eating. The results of demonstrations conducted on farmers' fields all over the country can be taken as good indications of what is possible of achievement. On a nation wide programme launched in the country, demonstrations are being conducted on farmers' fields to convince the clientele about the superiority of new technology over the methods in practice. The yield levels achieved for some of the field crops are given in Table 9, which speak for themselves. To produce what is needed by 2000 A.D. it is required to double or treble the yields of various crops as envisaged by the National Commission on Agriculture (Table 10), whereas the potential is 5 to 10 times with the existing technology. The scope for improving technology further is tremendous as seen from the possibilities observed in the worldwide studies going on with regard to improving photosynthetic efficiency, use of sea water for irrigation and ocean farming.

In conclusion, it must be said that the problem of food as stated by Sartaj Aziz, "is the most complex economic, political and moral problem of our times". It is not the problem of just increasing production. It is closely tied up with the problem of devising a system which will distribute purchasing power more equitably through increased employment opportunities for all and to minimize average ecological costs of attempting to produce the needed food. The social and economic components of technical change will have to be studied systematically to identify and remove the constraints in this regard as and when they arise. It is, however, still a manageable one; but it requires tremendous efforts at international, national, State and even at individual farm level.

Many experts of world repute have studied the food problem of India and have come to the same conclusion that it is possible to feed the increasing population for a long period. David Hopper, President of International Development Research Centre, Ottawa, Canada, concluded his Coromandel Lecture on 5th January, 1976 as follows:

> "The nation has the physical and human resources not only to meet the challenge of the future, but also to contribute mightily to total world food output. Focussed and sustained policies for food output growth vigorously pursued over the next decade can and will make this country securely food self-sufficient, even place it firmly in the ranks of the great world food producers. The task now is to build a vision of Indian agriculture as a modern economic sector of a modern nation. And to act to make this vision a reality. The beginnings have been made and given the political will for purposive and enduring action, I have no doubt there will be food abundance for all".

May I conclude with the hope that the needed urge will develop in all concerned to reach the achievable goal and we, scientists, technologists and engineers, will be able to play our due role in this exaiting game of providing food for the millions ?

REFERENCES

1 Report of the National Commission on Agriculture: January 1976

2 Proceedings of the World Food Conferences

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TABLE 1 PROTEIN AND CALORIE INTAKES IN DEVELOPED AND DEVELOPING COUNTRIES

Country	Protein (g)	Energy (cal)
Australia	92 (61)*	3,140
New Zealand	105 (72)	3,490
UK	89 (52)	3,280
USA	92 (65)	3,100
China	59 (8)	2,010
Sri Lanka	45 (9)	2,050
India	52 (6)	1,980
Japan	69 (17)	2,230
Malaysia	52 (9)	2,340
Philippines	47 (13)	1,870

*Values in parenthesis refer to animal proteins

TABLE 2 WORLD DEMAND FOR CEREALS 1970 ACTUAL; 1980, 1990 AND 2000 PROJECTED

(million tonnes)

YEAR	WHEAT			COARSE GRAINS			RICE			TOTAL
	Food	Feed	Total*	Food	Feed	Total*	Food	Feed	Total*	
1970	215.7	69.4	332.5	142.8	384.4	566.0	270.0	4.6	310.5	1209.0
1980	253.2	93.7	403.7	172.3	465.8	733.7	346.7	8.2	400.1	1537.5
1990	303.0	118.4	489.8	209.0	597.8	927.1	424.8	12.8	493.4	1910.3
2000	368.8	152.6	601.3	252.8	780.1	1186.6	543.5	20.6	633.6	2421.5

*Includes other uses

TABLE 3 WORLD: PER CAPITA DEMAND FOR FOOD 1970 ACTUAL; 1980, 1990 AND 2000 PROJECTED

YEAR	Population (millions)	Calories (per day)	Proteins (grams per day)
1970	3621.0	2480	69.0
1980	4401.0	2562	71.1
1990	5345.9	2665	74.2
2000	6253.3	2746	76.1

TABLE 4 AVERAGE INTAKE OF NUTRIENTS IN DIFFERENT STATES (1968-69)

(per capita per day)

State	Calories	Protein (gm)		Total fat (gm)
		Total	Animal	
Andhra Pradesh	2,040	53	5	21
Bihar	1,865	56	3	13
Gujarat	1,612	54	2	13
Jammu & Kashmir	2,265	63	1	25
Kerala	1,842	47	11	25
Madhya Pradesh	2,779	98	7	45
Maharashtra	2,281	68	6	30
Karnataka	2,220	66	3	18
Punjab	2,832	84	16	52
Rajasthan	2,044	77	5	34
Tamilnadu	1,498	36	4	12
Uttar Pradesh	2,307	66	5	32
West Bengal	1,927	48	7	24
All India	1,985	55	6	24
Suggested allowance	2,400	44	-	-

TABLE 5 PER CAPITA AND AGGREGATE GROSS DEMAND (EXCLUSIVE OF EXPORT DEMAND) FOR SELECTED FOOD ARTICLES

ITEMS	1971		2000 AD			
	Per capita (kg/year)	Aggregate Mt*	Per capita LOW	Per capita HIGH	Aggregate LOW Mt	Aggregate HIGH Mt
Foodgrains	171.25	107.9	179	194	205.3	225.1
Sugar	7.32	11.5	11	14	24.0	29.9
Gur(Jaggery)	13.5		15	18		
Vegetable Oils	3.3	3.2	4	5	8.3	10.2
Vanaspati	1.07		1.8	2.5		
Milk	39.42	21.7	53	69	49.4	64.4
Egg	10.9 (number)	6,040 (million)	18 (number)	30 (number)	17,419 (million)	28,513 (million)
Meat	1.25	0.7	1.7	2.3	1.6	2.1
Fish	2.9	1.8	3.8	4.8	4.6	5.5

*Mt = Million tonnes

TABLE 6 SUPPLY-DEMAND BALANCES - 2000 AD

Item	Unit	Supply Possibilities high	Supply Possibilities low	Domestic Demand high	Domestic Demand low
Foodgrains	(M tonnes)	230		225	205
Oils	(M tonnes)	9.7		10.2	8.3
Sugar & Gur	(M tonnes)	41.0	32.5	29.9	24.0
Milk	(M tonnes)	64.4		64.4	49.4
Eggs	(M numbers)	27,882		28,513	17,419
Meat	(M tonnes)	2.10		2.11	1.57
Fish	(M tonnes)	8.0		5.5	4.6

TABLE 7 PROJECTED LAND UTILISATION PATTERNS -

(Mha)

Classification	1970-71	2000 AD
1. Area under forest	66.0	70.0
2. Area not available for cultivation	45.4	56.0
(i) area under non-agricultural uses	16.2	26.0
(ii) barren and unculturable land	29.2	30.0
3. Other uncultivated land excluding fallow land	33.8	29.0
(i) permanent pastures and other grazing land	13.3	15.0
(ii) land under misc. tree crops and groves not included in net area sown	4.4	5.0
(iii) culturable waste	16.1	9.0
4. Fallow land	19.7	13.0
(i) other than current fallows	8.6	5.0
(ii) current fallows	11.1	8.0
5. Net area sown	140.4	150.0
6. Total reporting area	305.3	318.0
7. Area for which no returns exist	22.7	10.0
8. Total geographical area	328.0	328.0

TABLE 8 ESTIMATES OF AREA (GROSS) UNDER DIFFERENT CROPS IN 2000 A.D.

Crop	Area M ha		Projected irrigated area M ha
	Present	Projected	
Rice	37.54	32.00	24.00
Wheat	18.01	17.55	14.90
Other cereals	45.57	48.50	6.99
Pulses	22.15	25.00	5.37
Total foodgrains	123.27	123.05	51.26
Oilseeds	16.34	24.50	5.10
Sugarbeet	-	0.50	0.50
Sugarcane	2.59	5.00	5.00
Tobacco	0.45	0.55	0.40
Cotton	7,60	11.50	7.50
Jute	0.78	1.00	0.80
Other bast fibres	0.493	0.525	0.21
Total commercial crops	28,253	43.575	19.51
Vegetables and miscellaneous field crops	3.268	8.798	4.485
Fruits	1.80	4.00	1.25
Total plantation crops	2,317	2.876	1.00
Fodders	6,91	16.50	6.50
Grand total	165.818	198.799	84.005

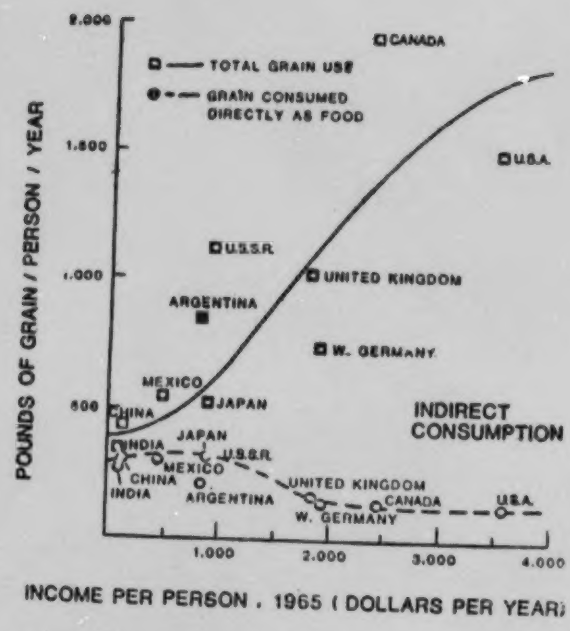

Fig. 1 : Grain use in relation to income per person in some of the countries

TABLE 9 : YIELD LEVELS OBTAINED IN DEMONSTRATION PLOTS AS AGAINST NATIONAL AVERAGES (Q/HA)

YEAR	PADDY			JOWAR			MAIZE			RAGI			WHEAT		
	N A	N D A	NP(ND)	N A	N D A	NP(ND)	N A	N D A	NP(ND)	N A	N D A	NP(ND)	N A	NDA	NP(ND)
1971	11.23	56.86	133.00	4.66	35.96	85.00	12.79	37.89	75.34	8.72	35.46	60.00	13.07	40.80	90.00
1972	11.41	55.18	130.12	4.60	42.61	97.12	9.00	39.17	93.42	9.11	33.79	60.00	13.80	45.01	87.00
1973	10.70	52.17	132.50	4.49	30.74	81.25	10.94	38.59	90.37	8.26	33.62	63.00	12.71	33.02	92.06
1974	11.51	52.70	107.88	5.44	32.17	95.50	9.65	34.84	88.50	8.78	33.22	61.69	11.72	37.03	87.00
1975	10.45	48.18	142.00	6.43	38.73	66.00	9.48	36.56	69.90	8.67	31.71	48.00	13.38	34.47	85.00
1976	12.35	51.49	130.00	5.91	35.54	67.50	12.00	32.28	95.00	10.64	27.81	40.75	14.00	38.14	81.00

N A - National Average; N D A - National Demonstration Average; NP(ND) - National Potential (ND)

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TABLE 10 PROJECTIONS OF AREA (GROSS), YIELD PER HA. AND PRODUCTION FOR 2000 A.D. OF IMPORTANT FOOD CROPS

CROP	Area M ha		Projected Production M t	Yield P/ha	
	Present	Projected		Projected t/ha	Present Yield t/ha
Rice	37.50a	32.00	80.00	2.50	1.10
Wheat	18.01a	15.25	59.00	3.87	1.30
Maize	5.80a	6.70	17.75	2.65	1.05
Jowar	17.60a	15.60	18.72	1.20	0.48
Bajra	12.40a	11.00	13.75	1.25	0.50
Ragi	2.60a	2.50	5.25	2.10	0.84
Gram	7.91b	7.91	11.87	1.50	0.64
Pigeon Pea	2.35b	2.35	3.53	1.50	0.71
Groundnut	7.20a	8.00	11.20	1.40	0.78
Sugarcane	2.59a	3.62	319	88	49
Fodders	6.91a	19.00	570	30n	30
Vegetables	0.90c	4.00	100	25	8.72
Fruits	1.80	4.00			

(a) average of 1969-70 - 1971-72
(b) value of a single year 1971-72
(c) average of 1968-69 - 1970-71
(n) calculations based on present level of yield (green fodder), but suggestions made for bettering the standards

RE-ORIENTATION OF TECHNICAL EDUCATION

Prof N S Ramaswamy*

India can be legitimately proud of the excellent technical institutions for Engineering Education. Compared to even developed countries, our technical facilities as well as teacher-man-power are outstanding. However, our approach to Engineering education, particularly in regard to structure and the content of the curricula, has not taken into account the Indian realities. Generally speaking, the curriculum of IITs and the Engineering colleges are qualitatively same. That is, it assumes, that end products should have the same kind of knowledge and skills. Each institution may give a variety of specializations, and may even give differential emphasis to specific aspects of the engineering subjects. But the overall goal and theme are essentially same.

It is not always realized that the products of these institutions take up jobs in the world of work, which require different kinds of knowledge, skills and attitudes. For instance, some go into the field supervising workmen as is the case in the construction of dams, buildings and bridges. Some of them work in power station doing essentially supervisory work and occasionally getting involved in maintenance of turbines and equipment. Some others are engaged in largely paper work and administrative chores. A few of them get involved in Engineering Design in Design organizations as well as in the Production Engineering Departments of Engineering industry. Many go for marketing of Engineering goods. In recent years many take up Management degrees, where they take a lot of effort to forego Engineering and learn managerial know-how. A few go for higher education in Science and Technology and become researchers and teachers. Even within the same industries, such as Engineering and Processing Industries, the job assignments vary considerably requiring different kinds of skills.

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In addition to all these as they go along in the hierarchy - the next ten years or so - the mix of job of skills required changes. At one end they need the knowhow and skills related to their specialization, be it Civil Engineering, Mechanical Engineering, Electrical Engineering or Metallurgy. But at the other end they have to interact with people - Supervisors, subordinates and colleagues. They have to analyse situations involving Technology, Economics, People, and organizational norms. In many cases they have to get involved with legal matters and environment. The latter part can be considered to be the 'group component', or it can also be called the organization and management component. Except the few who are either teaching or doing fundamental research, everybody else is, to some extent or other, involved with Economics and Statistics on the one hand and Sociology and Psychology at the other in their job relations and inter-personal relations in an organization.

Should the Engineering Colleges and IIT's take cognisance of this and do something in their curricula to take into account the job content, or should it only be worrying about Engineering, Science and Technology? Is training of the mind confined to Engineering and Sciences? I do concede that engineering colleges and IITs do give a certain amount of liberal education by including Economics and other humanities subjects. But today it is done more as a ritual. Students also, by and large, do not take them too seriously.

Though I will not be able to prove this, it is my impression that our engineering curricula today is one that would fit in well for an advanced country, and not for a country at our stage of development. But this is not to say that we do not need this kind of education at all. A few out of 10,000 and odd graduates passing out must have the present philosophy and structure of curriculum. The large majority of others might benefit by a different kind of structure of curriculum. This is because the job content of most of the persons entering Engineering career is entirely different from what has been supposed by the Educators in the Engineering field. Perhaps, I am exaggerating; but, this is only to drive a point.

It seems to me, that Engineering institutions should atleast offer some electives in order that those who wish to opt for different kinds of know-how and skills will have the opportunity to do so. In broad terms, the bulk of the technical man-power (and not all) can be considered to be entering in the following four broad categories of jobs.

A. Engineering Managers and Administrators, Techno Managers, Entrepreneurs, etc. Such persons do not normally do design work on their own, and are mostly concerned with management. They should have an understanding of engineering and technology but not the skills expected of designers.

B. Operating supervisors and Technical Personnel. They are directly concerned with shop floor level production, field operations. maintenance and such other jobs, which will have an interface between engineering and supervision.

C. Design and Development Engineers. These are personnel who work as Process planners, Product Engineers, Production Engineers, Tool designers and such other design personnel, who are largely spending most of their time in design offices.

D. Researchers, Teachers and Scientists who could be considered as the fundamental scientists.

What is given above is a broad categorization, though one can of course attempt a more precise and elaborate classification. This analysis is largely to understand the curriculum - in terms of knowledge, skills and attitudes - to be developed in the students. We can consider the above four as four streams for purposes of planning the curriculum in the Engineering Institutions. It is recognized however that engineers will migrate from one stream to the other depending on opportunities, circumstances as well as aptitude. Only training can take care of such situations. Our main concern now is to see what we can do at the engineering institutions to prepare people for these four kinds of streams.

We can see some broad patterns amongst the four streams. For instance, stream A needs a lot of managerial capability, while stream D needs the least amount of managerial capability. But, at the other end, stream A does not need high academic or scientific rigour in the engineering subjects, while stream D needs a great deal of scientific and engineering rigour. Thus, there is a trend between A to D and D to A. Interaction with people, organization and environment is highest in stream A, and lowest in stream D. Interaction with the world of knowledge, scientific developments, etc, are highest in stream D and lowest in stream A. Decision making is frequent and vital in A, while it is lowest in D. Complexity of the situation arising out of interaction between technology, science, economics, people, organization, legal matters, government, environment etc, is highest in A. Managers and Entrepreneurs have to have skills of communication, leadership, decision making, persuation and so on; and they have to work largely in groups, while stream D needs lowest of these attributes (though, of course, they also need certain amount of these skills).

The students also have different aptitudes. Some are extroverts while others are not so exuberant about mixing with people. Some have organizational ability, while others prefer to work alone. Some like to be scientists, teachers, designers as they would like to work on their own skills, while many others would like to get things done through the effort of others. Thus, there is a great deal of polarization amongst students based on their own innate abilities, upbringing, aptitudes, etc.

Students who enter engineering colleges do not normally have, at the time of entrance, much idea of their aptitudes and of their capabilities. By the end of the first two years, they can be expected to get some understanding of their aptitudes and skills. Therefore, it would be nice if appropriate elective courses are given in the 3rd, 4th or 5th year, which will enable the students to take the right kind of courses to suit their temperament and the careers they want to choose.

To understand the above argument better, we can consider all jobs to contain two distinct components: a specialization component (engineering, technology, medicine, law and order, revenue collection, etc) and a group component (organization, management, systems and techniques, etc,). Since results can be produced only through activities, group component (which includes management expertise) becomes extremely important. As we move up in the hierarchy of any job, the specialization component becomes less and less and managerial component becomes more and more. For different types of jobs different proportions of skills, at different levels of responsibility are needed.

In the case of jobs done by engineers, the specialization component is engineering or technology. In the group component which includes organizational and management expertise, three different types of skills are required. These are: technique-skills, relational skills and conceptual skills. A detailed note on this concept titled 'Specialization and Managerial Skills' is given in Appendix A. The required mix of these kinds of skills will largely depend on the nature of the job, type of industry, level of responsibility, etc.

Let us see how the job content/skills required for the four different kinds of technical manpower we have talked about earlier, differ from each other. Fig 1 shows the job content analysis of the typical engineer-administrators. For different types of jobs even at the lower levels of responsibility the proportion of specialization component is not very high. He is expected to be able to appreciate basic engineering/scientific principles relevant to his job; but in addition he should possess considerable technique skills and relational skills, the requirement of the latter increasing with increase in level of responsibility at the expense of both specialization component and technique skills of group component. Typical examples of this kind of a job will be that of a stores officer of a large engineering firm, or that of a sales manager of a firm selling industrial products.

On the other hand, the mix of skills required for a fundamentalist, viz, an engineering scientist or researcher is quite different (Fig 1). His job does not involve much of decision making, for which group component is more important. But we find that the proportion of specialization component for such a job is quite high. Moreover, a researcher's involvement in 'people's problems' (as a result of controlling or co-ordinating activities) is likely to be minimal, leading to the lesser emphasis on relational skills. The contrast is even clearer when we look at the relational skills needed by the shop-floor personnel, who have to control and co-ordinate number of subordinates. The logic behind the other figures is similar.

It can be seen that conceptual skills needed generally increase with increasing levels of responsibility. For the engineering-administrators especially, the necessity to visualize the impact of the decisions made, on the individuals, the organization, and the environment, is very significant, calling for an appreciable extent of conceptual skills. The head of even a highly specialization-oriented organization, (like Research Laboratories), will have to possess considerable conceptual skills to guide the activities of the organization to meet the needs of the environment.

From the illustrations above it can be seen that those who are likely to follow streams A and B (engineering-administrators and Production/Maintenance personnel) should be exposed to a great deal of social sciences, and skills in industrial engineering and management science. Those in categories C & D (Designers and Scientists) should be also given a minimum amount of social sciences and management to equip them to handle newer and broader responsibilities as they move up in the hierarchy.

Similarly, the mix of skills needed also varies, according to the type of industry in which the engineering personnel are employed. Limiting just to two kinds to illustrate the point, we can easily see that the proportions of different skills needed for a continuous process industry, such as petroleum refining or chemical industry, is considerably different from those needed for a heavy engineering firm. The former employs much less number of personnel compared to a similar sized unit belonging to the later category. As a result, performance effectiveness is less likely to be based on relational skills, in the case of continuous process industry whereas heavy engineering firms employing thousands of workers, require personnel who are effective in human relations.

Presently, a typical engineering or technology student, within any branch of engineering, goes through more or less the same curriculum. The assumption seems to be that, whatever be the type of job, the same curricula will produce the required know-how and skills. Unfortunately, the distinctly different needs of different types of jobs and industries are not taken into account in preparing engineers. This situation should be corrected.

The engineering education, though highly sophisticated, has not had much interaction with the Indian realities. The typical example which I always quote is that they are unable to tackle the problems of Indian masses, like re-design of the bullock cart, design of pumps which will have the least problems of maintenance, design of a bicycle which will suit Indian conditions, design of ordinary items used by the common man, etc. In fact, their application of mind for the problems of masses has not been given a chance for development. Also, there is an urban bias in the engineering value system.

India's main problem is one of organization, management and leadership. Therefore, all the more the reason we should introduce courses on communication, interpersonnel skills, leadership, decision making, productivity, small scale management, etc, for everybody. More so, in engineering education, where the need is highest, since engineers whereever they work have a lot of interaction with people and environment.

APPENDIX - A

SPECIALIZATION AND MANAGERIAL SKILLS

Most progress -industrial, economic, social and political takes place through the combined efforts of individuals working in groups. Members of such groups will have different specializations- scientific, technological, technical, functional, sectoral, etc. It has been said that mankind's progress has taken place by way of increasing specialization on the one hand, and improved group effectiveness at the other. The same idea has been said in different words- 'Progresstakes place through science and technology on the one hand and social organization at the other'.

The full potential of the various specializations, including science and technology, cannot be attained without proper social organization- each suited to the specific objectives. Social organizations are of numerous kinds- big and small- each having its own goals and objectives. All of us belong to one or more of such social organizations. Millions of groups, and sub-groups- arranged and interlinked in thousands of forms- form the social organization structure. Effectiveness of such groups depends upon the quality of organization, systems management, leadership, etc.

Every job contains a specialization component and a group component. The proportion between specialization component and group component will vary from job to job, level to level, industry to industry, etc. Also, the proportion of specialization component becomes less and less at the higher levels of any hierarchy and the group component becomes more and more at higher levels. For specialization component, one needs specialization skills. For the group component, one needs group skills and management skills.

Specializations are of various kinds and categories:

(a) Science specializations are:
Physical science, atomic science, space science and the like.

(b) Typical technological and engineering specializations are:
Civil engineering, Telecommunication engineering, Metallurgical engineering, etc.

(c) Technical specializations are:
Law, Medicine, Teaching, Research, Criminology, Law and order and the like.

(d) Sectoral specializations are:

Agriculture, Industry, Transportation, Education, Health and the like.

(e) Functional specializations are:

Purchasing, Selling, Accounting, Recruitment and the like.

Skilled jobs like carpentry, masonry, tailoring, catering, draughting, etc are also specializations.

In most cases, specialization will be a mix of the above kinds. In the initial stages of one's career at lower levels- most jobs contain a great deal of specialization which, obviously, need specialization knowledge and skills. For improved group effectiveness, it is necessary that members of the group should understand each other, adjust and adapt to each other's requirements (functional, professional and personnel), co-ordinate each other's activity, communicate among each other, etc. Attributes and skills required for these aspects can be termed, skills for group effectiveness. When different specializations are involved in the tasks of a group for accomplishing goals, work has to be assigned to different specialists and at different levels. There are a number of organizational principles which will affect the effectiveness of the groups Also, good systems and procedures would improve organizational efficiency through group processes , such as; consultation and participations for decision making, developing perspectives, etc.

Whenever a group is given a task to perform, one person has to be given the responsibility of directing and controlling the work of others in the group. He can be termed the manager; perhaps, it is more correct to say that this person, who directs and controls others, has a management component in his job (besides his specialization component). As mentioned earlier, the proportion between the management component and specialization component would vary from job to job and at different levels- each component requiring appropriate knowledge and skills.

In the management component, one needs managerial skills. Managerial skills can be acquired through on the job/project training and through experience as well as through formal class room instruction.

Managerial skills also can be divided into three parts:

(a) Systems and technique skills

(b) Human Relations skills

(c) Conceptual skills

Systems and technique skills help in the following:

(a) Evaluation of operational and economic consequences of various courses of action in particular situations.

(b) Assessment of the technical and operational ability of different proposals

(c) Reduce waste through methods improvement and planning

(d) Reduce cost through increased utilization of capacity and productivity

(e) Better allocation of resources for optimum efficiency

(f) Controlling cost operational factors, time schedules, etc

(g) Co-ordination among numerous activities and functions, etc

Typical systems are:

Budgetting, forecasting, controlling, planning, recruitment, evaluation, information computer, etc.

Typical techniques are:

Methods study, work measurement, inventory control, ABC analysis, PERT-/-CPM, linear programming simulation, etc.

Human relations skills relate to such knowledge and skills which gives an understanding of human beings and their behaviour, and getting the best out of them in given situations. Specific skills associated with human skills are: communication, motivation, leadership, counselling, etc.

Conceptual skill is the ability to understand the system as a whole in terms of the component parts forming the system, the inter-relatedness of each component part, impact action of one part on the rest of the parts, impact action on parts and the whole system, impact of present action on future, etc. It is also the skill to evaluate the relative intra and inter- consequences of factors, such as: technology, technical, economic, social, political, etc. It is also perspective skill, which needs a great deal of maturity and judgement. Perspective skill is also problem solving, diagnostic and analytical skill. Decision making is the ultimate state of conceptual skill. As one goes up in the heirarchy, one needs more and more of conceptual skill. The relative proportion of those different kinds of skill will vary from job to job. For instance, in the case of a Chief justice, the job is still highly specialization, while, in the case of the Chairman of a company, the job is essentially managerial and conceptual in character.

There is also constant inter-action between specialization skills on the one side and the different kinds of managerial skills at the other. Each skill strengthens the other skill, like the warp and weft strengthen each other.

Fig 2 shows the relative skills required at different levels of the heirarchy.

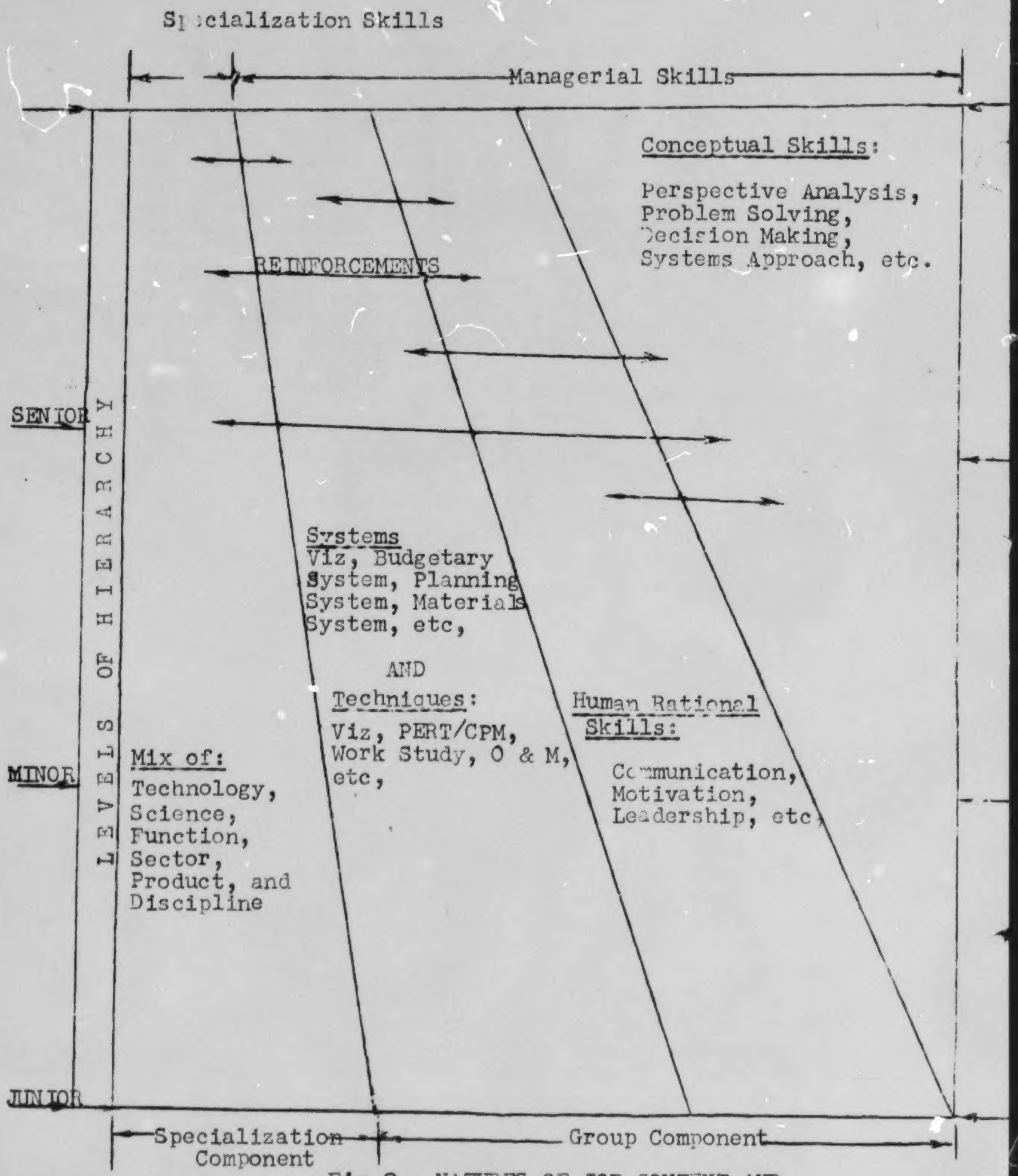
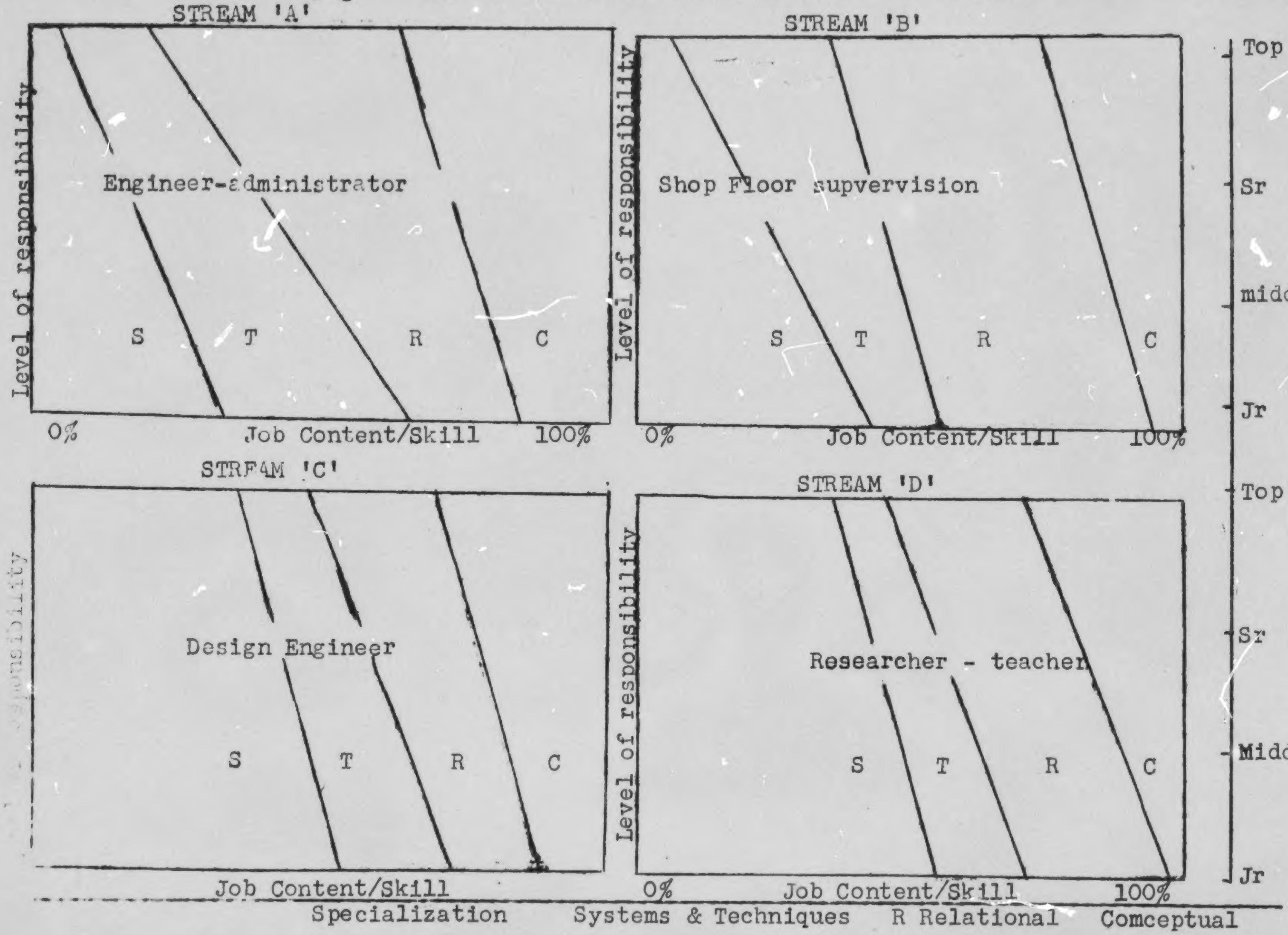

Specialization Skills
Managerial Skills
Conceptual Skills:
Perspective Analysis,
Problem Solving,
Decision Making,
Systems Approach, etc.
REINFORCEMENTS
SENIOR
MINOR
JUNIOR
LEVELS OF HIERARCHY
Systems
Viz, Budgetary
System, Planning
System, Materials
System, etc,
AND
Techniques:
Viz, PERT/CPM,
Work Study, O & M,
etc,
Human Rational
Skills:
Communication,
Motivation,
Leadership, etc.
Mix of:
Technology,
Science,
Function,
Sector,
Product, and
Discipline
Specialization
Component
Group Component

Fig 2 : NATURES OF JOB CONTENT AND SKILLS AT DIFFERENT LEVELS OF HIERARCHY

Fig 1 : MIX OF SKILLS FOR DIFFERENT TYPES OF JOBS



SESSION—4

NATIONAL SEMINAR
ON
EDUCATING THE ENGINEER OF THE FUTURE
BANGALORE, JANUARY 7-10, 1979

General Address by Dr S M Patil

ADDRESS BY SHRI S M PATIL

We have been talking on the subject of appropriate technology, solving the problems of the future unemployment, population explosion etc. We have been trying to find an answer which is impossible, I suppose, by 2000 A D. More than 75% of our population is today underemployed or unemployed and live below the poverty standard. What is more urgent, therefor, is that we should provide them with jobs. This is a difficult problem that the country will face in the next 25 years. This will get more aggrevated because the people who will be wanting to work, will increase to 300 million and perhaps double that figure with much less scope of job availability. We have this problem on the one hand and the other side is the appropriate technology so that we create jobs, which are more labour intensive than technology intensive. I spoke at a recent seminar on appropriate technology in U N of manufacture of capital goods like machine tools. I have been myself not been able to give a conclusive answer to their problem and it is difficult to find one because one cannot go on being a second class citizen in the world community as yesterday, though the country over the period of 30 years acquired an expertise the like of which does not exist in many of the Asian countries today apaet from Japan.

Appropriate technology means not a low technology nor a less high technology but is appropriate for the production of goods and services in the interest of society and the other social and economic problems surrounding us. Hence, we should have low technology, and we should have also very high technology depending upon the situation. In this, we cannot ignore, to be left behind. We have to advance to space, sea and in all directions and acquire the highest technology possible and assimilate, apply and adopt it to suit the various conditions of manufacturing a product or rendering a service. At the same time, we have also to think in terms of social and community responsibilities and see whether the technology percolates the biggest benefit to the lowest segment of our society. In this, we as engineers have to play an important role. Engineers have been left out in the stream of administration and hence, in the last 25 years we including myself have been propagating that engineers should not only be engineers and produce and sell, but also manage and administer. Basically we have to produce and we have to be the masters and avert appropriate technology. Therefore the responsibility, on engineers shoulders is much more than on any other professionals.

Shri S M Patil is Chairman, Hindusthan Machine Tools Ltd, Bangalore

SESSION—5

NATIONAL SEMINAR
ON
EDUCATING THE ENGINEER OF THE FUTURE
BANGALORE, JANUARY 7-10, 1979

Keynote Address **by** **Shri B G Shirke**

Keynote Address by Dr Jagdish Narayan

TECHNOLOGIES REQUIRED - MASS HOUSING

B G Shirke*

PREAMBLE

The speaker has broken the vicious circle whether prefab mass manufacture first or assurance of prefab adequate sales and use with continuity first, of whether the 'hen first or egg first' by creating the hen - in fact, half a dozen hens, and he now finds that our own administrative and technological conservatism and adherance to 'Status Quo' are preventing the hens to lay eggs at full capacity for the benefit of our houseless millions!

Points covered by this talk are mostly based on experience of the speaker. The talk will cover inter-alia the following:-

(i) Why are we having the mass housing problem?

(ii) What are the remedies? Most other countries have solved and are solving this problem. Why are we lagging behind?

(iii) What are the road blocks, who can remove the road blocks, how to remove the road blocks?

(iv) How can we have economic and speedy mass housing?

(v) What appropriate technology? What kind of prefabrication?

(vi) What are the pre-requisites for mass housing?

(vii) There is now national consensus as to what should be done for creation of ample mass housing. Why it is not being done? Why outpourings of various Seminars and Housing Conferences do not get implemented in actual execution? Missing link between the brains and the limbs? A general paralysis?

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* Managing Director, Siporex India Ltd, and Chairman, Shrike Group of Industries, Poona.

As to conditions that might obtain in 2000 AD, it is anybody's guess and the field is wide open. One thing is certain the future engineer must be 'all in one' and not only expert in his particular discipline. At present he remains mostly aloof from the political, social and community problems.

By 2000 AD our population will be more than double itself. If the nuclear holocaust occurs before that, everything will vanish including our housing and other problems. All our procedures, norms, rules, moral and other standards have been based on conditions when the population was far less. We are desperately trying to adhere to these even when the basic conditions have radically changed, that is why in every field of human endeavour there is disruption, unrest and practically chaos. We have no precedents, when the population was so immense, to go by. In present times China is the only country that was as poor and populated as India. They solved most of their problems of floods, draughts and limited technologies and resources by making full was of their population in all fields, thus turning a handicap into an asset which we must emulate. When the population is so big, individualism has necessarily to be mostly set aside, community kitchens, community efforts, industry and agriculture have to be resorted to. As to housing technologies that might emerge, there are some portents of a common community or town roof using modern advanced materials and techniques.

However, we have to be more concerned with our present conditions and problems and if these are rightly tackled and solved, the speaker is confident that we may be able to tackle the future problems also.

WHY ARE WE HAVING HOUSING PROBLEM?

The housing demand far exceeds the supply due to our restricted laws, procedures, heavy taxes, craftsman-oriented 'casting-in-situ', slow, wasteful multi-storeyed construction methods, scarcity of skilled workers and craftsmen and of building materials and mainly on account of non-adoption of modern industrialized technologies of manufacture and mass housing.

WHAT ARE THE REMEDIES?

Now there is countrywide consensus as to the remedies which are:

(a) mass manufacture and use of worthwhile prefabs for columns, beams, floor and roof slabs and walling etc that conserve our limited natural national resources in good agricultural soil, coal, energy and timber and effect economy in use of our scarce and costly materials like cement and steel.

(b) Adoption of industrialized prefab housing methods.

(c) To overcome the separatist and lone working of various agencies involved in provision of essential pre-requisites such as land and services, finance, materials and prefab manufacture, builders etc by forming of tie-ups-cum-multi-disciplinary consortia.

(d) Administrative reform by making our procedures conducive to full use of these remedies and removing the various road blocks that come in the way of progress.

(e) Full use of modern developments of science and technology for 'doing more with less'.

(f) Establishing numerous 'Building Centres' for manufacture of worthwhile prefabs.

WHICH ARE WORTHWHILE PREFABS AND INDUSTRIALIZED HOUSING SYSTEMS ?

Merely precasting 1:2:4 reinforced concrete does not give the real and full benefits of prefabrication. The material must have integral multi-qualities:

(a) It should be lightweight and having high strength-weight ratio, prefabs must not be unwieldy requiring special heavy equipment for transport, handling, hoisting and assembly. If need be, the components should be capable of being handled by manual labour.

(b) It must be suited to our conditions of roads and general technological level.

(c) If dense RCC is used, it must be of special high grade and the design must be sophisticated with low factor of safety possible due to rigid factory quality control.

(d) It must have good integral qualities of high insulation, fire resistance and incombustibility.

(e) It must use indigenous raw materials.

(f) The system must not be 'closed' but should be open and with the prefabs construction of all kinds and sizes of housing should be possible.

WHAT ARE THE ROAD BLOCKS? HOW CAN THEY BE REMOVED? WHO WILL REMOVE THEM?

(a) The main formidable road block shutting out alternative offers is the traditional procedure of calling item-rate ad-hoc tenders based on conventional housing designs only, thus prefixing all items, materials and methods.

(b) Even in cases where alternative designs and offers based on manufacturer's designs are called for, the next formidable road block is the straight comparison of only the quoted rates without establishing equivalence between the various systems by consideration of their plus and minus points.

(c) There are recent High Court and Supreme Court decisions of how such comparisons, treating unequals as equals, are against our Constitution, breaking the principle of equality, and therefore, ultra vires.

(d) Most of the road blocks in the way of progress are entrenched in our Governmental procedures which are also duplicated by institutions, architects and engineers concerned with housing. These procedures were framed when the population was less than half of its present strength and housing construction for rental was limited and mostly done by private individuals and bodies. Now due to various restrictions, laws, Acts and taxes the full responsibility for creation of social mass housing has fallen on Government but the restrictive procedures framed when conditions were totally different remain the same.

HOW THE IMPLEMENTATION LINK CAN BE ESTABLISHED AND WORKED?

(a) Without establishing a firm and effective implementation link between expert and scientific opinion and consensus as to what is required to be done on the one hand and with the administrative frame on the other hand for giving effect to same in execution - all academic discussions, talks, papers and deliberations and ministerial pronouncements as to projected ambitious housing programmes prove ineffective.

(b) What is required to be done is to establish new norms and procedures so that progress and correct actions are taken as a matter of routine. Government administration is procedure and precedent bound and top boss oriented. The top restricting authorities are mainly the accounts, audit, finance departments, the Accountant General and Comptroller of Accounts, Parliamentary Committees and estimates committees. These top controlling agencies set the pace by their repeated usual remarks, objections and calling of explanations for deviations from set procedures embodied in the departmental manuals and accounts and audit codes. That is why newentrants in engineering services in a short time become creatures of routine and outdated set procedures, losing their initiative and desire for innovative improvements.

(c) In fact, this state of affairs is all-prevading and very serious and holding back necessary progress in all fields of our national and social developments. Government Resolutions, Rules, Acts and even Laws framed for different conditions, invariably act as obstructions when conditions are totally changed, thus allowing great scope for corrupt practices at various Government levels. We have ourselves been forging shackles binding our feet and hands and even brains to such an extent that we are not even able to see and appreciate obvious advantages possible by different procedures and technologies etc even when these are very gainfully exploited by other countries.

(d) A recent illustration of how our own old and even new labour deployment and other procedures obstruct genuine exporters vis-a-vis the helpful and practical procedures of Governments like the South Korean Government in connection with execution of construction projects, particularly in the West Asian countries is very illuminating.

(e) The matter of weeding out such dead wood from our procedures, codes and manuals is so urgent, serious and fundamental that the time has now come to establish special Central and State Ministries solely for exercising constant vigilance - and getting obsolete old regulations, procedures, rules and even laws modified, and changed to suit present day conditions and requirements.

(f) Similarly, a non-cumbrous procedure for cancellation or changing of obsolete procedures and rules must be devised and operated.

(g) Unless this is done democratically and constitutionally and soon the general confusion, frustration and even fatalism are so widespread and all pervading that the way to authoritarian rule is slowly but surely being paved as has already happened in many adjacent countries.

RESEARCH AND DEVELOPMENT FOR HOUSING

(a) Our R & D in connection with housing is mostly restricted to technologies and materials. Actually R & D for housing must be comprehensive covering all the essential infrastructural prerequisites like land and services, finance, industries for manufacturing modern materials and prefabs etc. Research must be done as to why indigenous R & D buildings are not being commercially exploited or why even modern technologies and prefabs introduced in the country are not being widely used.

(b) We talk of low-cost housing, housing for low-income groups and social mass housing. There must be research to find out what has been and is being done in other countries in these fields so that we can emulate worthwhile and fruitful procedures and practices.

As far as 1968 the Planning Commission published a comprehensive report in connection with how construction costs can be reduced making clear suggestions. As a result only the 'National Building Code' has been published but all the dozens of points remain unimplemented.

There should be research as to why this has happened and what can be done to avoid such waste of national thinking and consensus.

(c) Before undertaking fresh and independent research, we must gather fullest world information and data of technologies, models and prototypes and purchase 'know-how' and then leapfrog as done and being done by Japan and other countries.

Ministers, Officers and numerous delegates go abroad for various purposes who could bring books - information and data regarding housing technologies and materials and prototypes.

The planning Commission as far back as 1968 strongly recommended that there should be a world technologies, information,data and materials National Bank about the Construction field.

(d) To encourage worthwhile new materials and prefab systems, we must have a national apex organization to test various new materials and prefabs, get prototypes constructed and tested and after such trials and tests are conducted to certify accordingly on the lines of the 'Agreement'. French System - NBO has to do the needful in this connection. It is not known what is done.

ACHIEVING ECONOMIC HOUSING CONSTRUCTION AND LOW COST

Unless worthwhile and proven prefab manufacturing industries are established and their production capacities are utilized fully with continuity - the product costs and of mass housing - will not be substantially economical. Our out-dated tendering procedures in use - preclude establishment and survival of such industries.

CONCLUSION

I shall not dilate on the other technological topics which are hardy annuals in connection with mass housing cropping up in Seminars and Conferences.

What I have stated is at the grass roots of the housing problem and I request all concern to do the needful in that respect.

FACULTY TRAINING FOR EDUCATION IN 2000 AD

Dr Jagdish Narain*

THEMES AND ISSUES FOR TRAINING OF FACULTY

I am indebted to The Institution of Engineers (India) for giving me this opportunity to share some of my thoughts with you, as to the overwhelming challenges that our runaway society will be facing with ever increasing urgency; and how we engineers will need to continually expand our horizons, explore new avenues and fashion imaginative pathways to confront these challenges. These critical tasks must be initiated at the very first stages of engineering education and that preparations to do so will naturally involve the prime agent of this exercise, that is, the faculty in our engineering colleges, institutes and universities. They will need to be maintained in an everfresh state of intellectual ferment and adventure, to be able to generate a continual stream of creative young engineers for solving tomorrow's problems. It is this emerging aspect of future needs of engineering education that I should like to dwell upon, in the hope that by anticipating these and clearly identifying our objectives and strategies, we should be able to steer society with confidence through a progressively tapering transition.

What are these new developing situations that call for a fresh emphasis? What are their imperatives and what implications they have to the structuring of our educational system generally, and to engineering education in particular? Let me digress here awhile towards the perspective of the emerging world order for the sustenance of which, radically different concepts, planning strategies and capabilities will be required.

THE SCENARIO OF 1979

Engineering education in our country has now come of age. We have over 120 engineering institutions producing 25.000 graduates in different branches of engineering every year, and over twice that number of diploma-holders in about 275 polytechnics. Besides, a large number of R & D institutions have also been developed over the years since independence to take technology to the people at large. As a result of these endeavours, we have been able to considerably augment our capacity for power generation, making it available to over 65% of our people including about 45% in the rural sector. We have more than doubled food production. We have been successful in training the third largest body of scientific and technical manpower in the world and have the seventh place in industrial production among the nations of the world. We have also attained critical levels of self-reliance in the vital fields of electronics, nuclear energy, defence production and some other engineering sectors. The rural scene, too, has witnessed some momentous changes though not as many as we would like to see. Most of the 500,000 villages are now marked for planned development through 5,000 Community Development Blocks and have some form of health, education and transport facilities, although mostly inadequate.

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*Vice Chancellor, University of Roorkee, Roorkee.

LOW PRODUCTIVITY SOCIETY

Despite many technological successes, however, India still remains largely a 'low productivity' and 'low technology' society. It is generally agreed that our existing technological system has failed to generate the essential survival needs of our people, while an ever-increasing number of left over people slide below the poverty line with every passing year. It is on this dramatic scene of painful contrast that we must pause to examine the structure of our technological system and assess its apparent weaknesses and inherent potentialities, particularly those relating to engineering education and more specificially to educators in the field. We must also seek a more comprehensive view of the nature of technology and its relation to environment society and its resource contexts and incorporate these in our educational planning and research. Equally significantly, we must recognize the larger role of the university in providing leadership through a total endeavour in technology planning, assessment, options, design and management.

TECHNOLOGY — A SOCIAL ACTIVITY

Technology is basically a social activity, a systematic and purposeful application of knowledge, skill and expertise towards the production of goods and services useful to man - an array of means, social, economic, political and engineering, designed and tuned to achieve the desired goal. It constitutes a set of inter-related innovations, both software and hardware, traditional and modern, to manipulate the environment in a purposive manner. As an engineer or technologist is the prime agent in harnessing the resources and environment for the benefit of society, his activities must multiply continually, in order to provide a modicum of basic necessities to each and every citizen of our country, and also to cater to the projected 100% increase in their numbers by 2000 AD. In fact, the engineering effort required to harness the resources for the benefit of a vastly increased human family, whilst preserving its wholesomeness and integrity, will be many times more than what the simple doubling of human numbers would suggest. First, because the remedial technologies needed for conserving our resources and environmental assets increase non-linearly with the intensity and extent of their utilization. The large scale pollution and host of irreversible imbalances created in the earth resources and ecology in the exercise of incompletely designed technological solutions have already brought about a widespread disenchantment with technology, which we engineers can no longer afford to ignore. The effect of reaping new benefits through the creation of new pathways for the flow of materials and energy in our society can become counter-productive, unless designed carefully and imaginatively to produce a net positive gain when weighed against the corresponding social, economic and environmental costs. The challenge of accomplishing this rather overwhelming task becomes clear if we appreciate the fragile nature of our biosphere which is precariously maintained within the narrow interfaces of the lithosphere, the atmosphere and the hydrosphere. Its dynamic equilibrium, achieved over long periods of time, can be all-too-easily shattered by human intervention aimed at engineering and modifying their natural pathways, unless we expand the body of our technological education to internalize this wider sensibility and create more viable conceptual frameworks for seeking solutions to problems of social development.

THE ENGINEER OF 2000 AD

A daunting task is posed by the requirements of large scale environmental manipulations to meet future needs. It stems from the fact that this will no longer be possible through conventional engineering means, which call for a proportional availability of conventional materials derived from our fast depleting stock of resources. Inevitably, therefore, most of the materials to be used by engineers in the future will need to be created out of the environment, which in turn, will have to be rendered adequately regenerative through new technologies. It should thus be clear that the total engineering effort needed in the years to come, will be much larger quantitatively and more sensible to social and environmental consideration. Technologies must be conceived and engineered which are specifically beneficial to our people and do not mortgage the future in an imprudent attempt to wastefully exploit our existing resources. Development of a whole gamut of 'Appropriate Technologies' for the diverse sectors of our economy , ranging from the most sophisticated and internationally competitive to the simple and traditional, with emphasis on design of most reliable systems, should be deliberately and assiduously fostered as the key principle of engineering education, practice and research in the coming decades.

THE UNEMPLOYED ENGINEER OF TODAY

It is indeed ironic that, with such crucial tasks awaiting to be performed for the accomplishment of which a very large number of engineers must be deployed, we have a backlog of over 40,000 graduate engineers and 75,000 technicians and diplomaholders, who remain unemployed. I do not suggest development on the lines followed in highly industrial societies of the West but it is notable that we produce about 50 times less engineers per capita annual than are produced in the USA and 30 times less than in Japan. The quality of life in a society is bound to be limited by the number of engineers available notwithstanding the differences in development goals and strategies to be adopted for their accomplishment. Thus, while technology is supposed to improve the quality of life, even the critical level of technological manpower has not been deployed for this purpose so far. Nor has there been any conscious attempt at defining development objectives that are technologically feasible and attainable, and the necessary manpower required to achieve them, except, in a very limited way in heavy industry.

MODERN ENGINEERING EDUCATION-TWIN ISSUES

It is obvious from the forgoing that engineering education, henceforth, must encompass not only hardware engineering and design but associated issues of socio-technological goal definitions, planning of total engineering strategies including that of technical manpower, and, most important, of management of complex systems which are bound to be dominated by human beings. The engineer of tomorrow would thus need to be also a scientist, a designer, a socio-economic planner and a manager. To my mind, there are two main issues confronting modern engineering education:

(a) Design of socio-technological system which will deliberately set out to improve the quality of life all round through a rational deployment of technological manpower, expertise and resources, and

(b) Design of a broad-based educational system to prepare engineers for their multi-dimensional roles as visionary scientists and humanists, planners, designers, executors and managers.

ROLE OF EDUCATORS

Our current engineering education system tends to be imitative rather than original, derived as it was from alien sources unrelated to our actual social needs. Since it already possesses a certain momentum, it can be steered on the new desired course only by recognizing the imperatives of our changed philosophy. This would necessarily imply recourse to radical rather than incremental solutions, which underline the inimitable role of universities and engineering institutions generally in seeking such solutions. There alone lie possibilities of venturing into unconventional avenues of thought and practice and providing a lead in the generation of new ideas and systems, as well as in the identification of new targets, new roles and new tasks. This in turn highlights the pre-eminent role to be played by the faculty in engineering institutions, who are the prime movers in affecting technological innovations and advancements in the accomplishment of the goals. First, they would need to engage in researches in identifying future scenarios and perspectives, realistic goal definitions, technology assessments and policy options relating to the choices of technologies related to the various social parameters involved. Secondly, in view of the high multiplier affect of their attitudes, visions, imaginations and capabilities through the students trained by them, they will need to continually refurbish their own grasp, sensibility and competence. Both the above challenges underscore the need for maintaining our engineering faculty in a state of intellectual vitality and adventure through built-in systems for their continuing education and cultivation both through formal instruction as well as self-regenerative approaches depending on the nature of their academic activities and responsibilities. Furthermore, a purposive and periodically renewable approach will need to be fostered to the acquisition, communication and application of knowledge whose frontiers and volume will continue to expand rapidly. In particular, they would need to be vested with an extraordinary dimension of inter-disciplinary thinking, practice, organization and teamwork.

FACULTY TRAINING

It should, of course be clear that necessary retraining of faculty on the above lines, will have to be conceptualized and structured by some members of the faculty, who may be specially charged with the responsibility of identifying future needs and designing effective training programmes. One way to accomplish this would be to constitute an education cell in each institution for continually reviewing the state and future needs of engineering education, particularly the continuing education programmes, which some institutions are already developing as their technology extension services. Faculty members from various disciplines with an interest in contributing to this activity could be attached to this cell for two years at a time to ensure freshness of ideas, approaches and strategies.

Learning programmes for the faculty should in particular, aim at keeping alive the following academic and research activities:

Development of Curriculum

The most important task in curriculum planning relates to the careful sifting of the conceptual aspects of wider applicability from the more specific and the transient. This is a task which will call for continual reordering of priorities as new knowledge accumulates and new challenges are anticipated, and should be the prime concern of the faculty working with the education cell. Further, the curricula should be so designed as to internalize the problems and criteria for definition of socio-economic objectives and development of a culture of technology assessment on the one hand and sensitivity to the needs and aspirations of our society on the other. This can be done by exposing students to short well-planned courses on the dynamics of social transformation and needs and on evolving effective mechanisms for technology transfer and diffusion, as a part of the regular curriculum.

Communication and Motivation

A curriculum is, of course, only as good as it is delivered. The latter involves the sensitive and imaginative process of communication and motivation and depends, in a rather subtle manner, on the vitality of the academic and research environments, obtaining in an institution. Both these tasks need continual reappraisal to be effective, and this is an area where considerable experimentation and corrective feedback will be needed. For example, to fire students' imagination and make them socially responsive, it is essential to create an intimate feel of ideas as well as to demonstrate to them their power in achieving desired ends. This can be accomplished through planning a course work, which is imaginatively illustrated with problem solving exercises and research and development projects on real world problems of relevance to the society.

Interaction with Industry

Built-in systems would need to be provided whereby our faculty have the opportunity to interact with industry. This can be effectively implemented through an involvement with and concern for the needs of industry as well as of the society at large, which would in turn require such knowledge and interaction on the part of the faculty itself. We should develop programmes for visiting faculty from educational institutions to spend part of their time in carrying out some of their research projects in industry, and of honorary/visiting professorships to enable scientists from industry to spend some of their time in educational institutions. The University Grants Commission has already set up the funding for these useful programmes. Such interaction would lead to more purposeful identification of research problems as well as of new courses for short and long period training programmes. They could thus prove to be a veritable catalyst in preparing resourceful engineers who would be able to face unforeseen problems with confidence and self-assurance. At the same time, educational institutions should provide a much-needed support to industry for their in-service training programmes.

Monitoring of all current research in engineering education and necessary feedback mechanisms are a prerequisite to the well-being of a self-regulatory system, such as our educational system ought to be. This should be effected through two channels, namely audience response in our institutions on the one hand and the views of our graduates and executives in industry on the other. Some systems in respect of the former are being experimented upon by various institutions. I have every hope that despite current apprehensions, the system will foster an all-round sense of purpose and responsibility. The latter is equally important and we need to look upon and use it as an important instrument of curriculum and research planning through active advisory boards which include eminent and broad-based scientists from industry.

Continuing Education

Considerable impact has been made in the development of faculty of colleges and universities by the Quality Improvement Programme and the Faculty Improvement Programme. These programmes need an effective monitoring, feedback and evaluation machinery, so that new ideas are injected at the right stage. Refresher and specialist courses are being organized by many institutions primarily for the benefit of practising engineers from industry and public undertakings. Similar courses must be planned and designed on national level for the educators to stimulate their thinking and tune them to the changing needs of appropriate technology and relevant research.

Planning and Coordination of Research

Research in technology has shown its positive impact on the Indian economy, and self-reliance has given us the much-needed confidence. It would not be an exaggeration to say that Indian economy has reached the 'take-off' stage. Greater input may be needed in the future but, probably, the more difficult stage has been crossed. Basic and applied research, undertaken by the teachers of colleges and universities, though a fraction of the overall national research effort, has a very significant role in setting the directions and goals for the future. Systems must be developed to ensure optimum planning and coordination of research work in different institutions, carefully avoiding duplication of work as well as expensive equipment, and maintaining the flexibility essential for creative thinking.

ROLE OF INSTITUTIONS OF HIGHER LEARNING

Finally, I must emphasize that our basic goals in bringing about a social transformation through a highly responsive technology will not succeed unless the instruments for ensuring a perennial vitality to our engineering education are made available at all levels of technological education throughout the country. This requirement is even more pressing at the moment in respect of regional engineering colleges and technological institutes. The institutions of higher learning can provide a valuable service to these colleges and institutes through carefully designed leadership programmes. A system was attempted in Britain during the last decade, whereby stronger institutions adopted a number of colleges in their respective regions with a view to raising their overall standards of teaching and research. There are doubtless some problems in adopting this system straightaway. For, the technical institutes fall under state control and are guided by supervisory boards which often lack an educational culture. But I feel certain that if our institutions of higher learning were to come out with concrete proposals to assist these institutes academically through some viable institutional system, it should not be difficult to persuade the state boards to allow the latter to benefit from such assistance. The Institution of Engineers (India) which has contributed over the decades towards the growth of engineering education, research and development can specially provide a lead in this direction. In particular, it could spawn a new division for engineering education which could devote itself to the educational planning of the total engineering system from the institutions of higher learning to the regional colleges and polytechnics. This division could also evolve suitable mechanisms for creating productive linkages between them and interact with the various government and private organizations involved in translating them into reality. Revitalizing the Indian Society for Technical Education is also needed so that it can play a more dominant role in giving direction to the engineering education in the country.

CONCLUSION

I should like to summarize the following proposals which may be considered by academics and government organizations towards vitalizing the intellectual and human equipment of our faculty in various institutions concerned with training engineers in the country.

a. Establishment of an educational cell in each of our institutions of higher learning for identifying requisite learning materials for the faculty, in the context of future developments, and evolve mechanisms for internalizing these.

b. Establishment of programmes of visiting scientists and honorary/visiting professorships to foster intimate involvement of the faculty with the emerging needs of the nation.

c. Designing suitable systems/mechanisms for monitoring the efficacy of existing educational processes, through audience response on the one hand and advisory boards consisting of representatives from user organizations, on the other.

d. Design of mechanisms by advanced institutions whereby the new philosophies and strategies of engineering education may be included amongst the faculty of other colleges and polytechnics in the region.

c. Creation of a new division for engineering education in the Institution of Engineers which could strive to create and maintain mutually productive linkages between various levels of engineering institutionsin the country.

Finally, I must thank you all for the patient hearing you have given me and express the hope that the proposals I have put forth will be examined, debated and experimented upon towards a constant striving for excellence in an exciting endeavour to put technical knowledge to the noble task of building a happier India of tomorrow.

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SESSION—6

NATIONAL SEMINAR
ON
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S-6

Keynote Address by Dr V C Kulandaiswamy

Keynote Address by Prof H N Ramachandra Rao

NON-FORMAL SYSTEMS OF EDUCATION IN 2000 AD

Dr V C Kulandaiswamy*

INTRODUCTION

All prediction about, and projections into, the future are based on an assumption of continuity in the progress of human civilization. Past experiences and a knowledge of the present trends are based as the basis for predicting the future. Such predictions can go substantially wrong, if there are abrupt major changes or breaks consequent on technological revolutions or cultural and political upheavals. An appraisal of the development in Science and Technology, and its possible impact at any given period of time, is necessary for making any attempt at predicting the future. In developing Countries, these are shrouded in considerable uncertainties and therefore, exercises in futurology are formidable tasks. The attempt made in this discussion is based on an extension of the present trends and surmises of what might be the possible future solution to the many present problems that loom large in the educational horizon.

ROLE OF EDUCATION

The term education is as old as civilization. But its role and relevance have been continuously changing. The transformation that has taken place in the 20th Century is rather far reaching.

- In the past, education was an ornament and an embellishment to an individual, and was not an economic or even social necessity. No Society depended on literacy or scholarship for food, clothing and shelter.
- In the Second half of the 20th Century, Education has become definitely an Economic necessity. An uneducated or even an inadequately educated nation cannot avail itself of the tools of Science and Technology for social and economic transformation.

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- In the past, only a rich nation can become educated; but today, only an educated nation can become rich.
- In 1900, in the USA out of 20 employees, 18 were hand workers, and only two were knowledge workers; but by 1970, of the same 20, only 5 were hand workers and 15 were knowledge workers. Even the five hand workers needed substantial education.
- The fact of the matter is that education has to be democratised and Universal Education has to be achieved not as Social Service, but as an economic necessity. The existing educational system has not been designed and developed for such a task.

The second important aspect is the rate of growth of knowledge. It is today a well known fact that in many areas of knowledge, the growth rate is nearly 7% and knowledge doubles every 10 years. Assuming that the professional life of an individual is about 30 years, there will be an eight-fold increase in knowledge. Obviously one cannot perform his job with competence on the basis of what he has learnt in School or College, and not many can continue to learn and keep themselves up to-date completely on their own. The Education system should be capable of meeting and catering to these changing needs. Consequent on these developments, two important and mostly new dimensions emerge, viz,

(i) The Conventional Education has a spatial restriction in the sense that it is confined to class rooms and educational campuses. The requirements of Universal education, and continuing education make it necessary that these barriers are removed and education takes place in all situations and in all possible places.

(ii) At present, there is also a temporal restriction to education. It is normally assumed that education is an activity in which one is engaged roughly between the 6th and the 21st or 22nd year. The rapid growth of knowledge and the fast absolescence rate warrant that one keeps learning during the entire period of one's career. In other words, education has to be a life long activity.

The above aspects have been forcefully brought out in the report of the UNESCO, titled the 'Learning To Be'.

The question now is, whether the existing educational system can meet the above requirements. The answer is in the negative.

LIMITATIONS OF EXISTING SYSTEM

The present system of education is not the one that has existed from the beginning. Two distinct stages can be seen in the growth of education, and we are entering now perhaps the third stage.

- The teacher-disciple (Guru-Sishya) system is perhaps the first well established method of learning. It was adequate during the entire period of agricultural civilization. Even today, music, dance and certain other subjects are learnt that way.
- With the progress of industrial civilization, and with the development of knowledge in a number of areas, it became impossible for any one individual to impart instruction covering the whole field. However gifted a doctor may be, he still cannot teach by himself all that is needed for a student of medicine. Besides, a relatively large number had to be handled to provide the necessary manpower to sustain the growth of industrial economy. Consequently the class room teaching as we now know, emerged in place of the Gurukula system and this perhaps is the second stage in the development of education.
- It is now realized that the educational needs of a 'Knowledge Era', cannot be met by the system of class room teaching because of its many limitations. What we now call as informal education, may perhaps become the main form of education in the coming decades and our vision of education in 2000 AD will have to be based on these considerations.

EMERGENCE OF NON-FORMAL EDUCATION

Higher education is an area in which India has made significant progress after independence. There may be controversies over the quality, and content but the observation made above is about creation of opportunities and the development of infrastructure. There are today nearly 120 Universities; 4,500 Colleges and 4 million students. Every State is spending about 25% to 30% of its budget on education in general. With all the expansion that has taken place only 6% of the students in the relevant age group are in colleges for higher education.

Considering even the growth of literacy, it was around 18% in 1951, and reached a little over 29% in 1971; an unenviable growth rate and we are told that with the increase in population, the illiterates have increased in absolute numbers during the above period.

A calm review of the position will indicate that the needs of democratization of education, and the problems of life long education cannot be handled by the class room instruction of the conventional education system. Consequently, the programmes of:

i. Correspondence Courses

ii. Open University

iii. University in the Air

and similar programmes must be seen not merely as additional avenues, but as the emerging alternatives with greater promise for the future. The future of non-formal education must be viewed from this angle.

NON-FORMAL EDUCATION IN 2000 AD

General

Progress in general, takes place either because of a change in the system, or because of a breakthrough in technology. In the field of dissemination of knowledge and spread of education, the first great breakthrough in technology was the invention of the printing press. For nearly 500 years thereafter, nothing very significant has happened. The next important development that the progress of human civilization has witnessed is the breakthrough in communication, thanks to the many inventions and innovations in electronics. The communication revolution is the harbinger of non-formal education, and non-formal education is important not because of the role it plays today either in this country or elsewhere, but because of the potential it has for meeting the future educational needs. Non-formal education indicates the emergence of a new system which employs new tools.

Lumped Versus Distributed Systems

The technologists are familiar with the concept of lumped and distributed systems. Socially and economically, the agricultural civilization was based on what can be called a distributed system. No activity was concentrated and no system was large and lumped. The dawn of industrial civilization and the advance in science and technology enabled the growth of large systems and concentration of people and production facilities. In the language of systems, education based on class room lectures represented what can be considered an open, lumped system.

The slogan that 'small is beautiful' represents only a nostalgia for what our forefathers had in a society marked by distributed systems. In order to have the 'small' and thereby the 'beautiful', we cannot march back to primitivity. The humanity marches forward and it is an unending journey of progress, striving for perfection. The achievement of the small and beautiful must therefore be through further developments and exploitation of science and technology and not through their abandonment. In my opinion, non-formal education will mean distributing educational opportunities and instruction in time and space and will be a transformation of the education system from lumped to distributed one.

Productivity in Education

Knowledge has been continuously growing, but 'education system' as such, has remained stagnant. In every field of activity, the use of methods of science and technology has brought about significant increase in productivity. Productivity in education has remained the same for centuries. The larger numbers and increased demands of specialization cannot be handled with the present level of productivity unless we convert half the population into teachers and the other half into students. A stage has now been reached when linear expansion cannot form the solution to the problem.

New System: New Tools

By 2000 AD, we will have a system in which organized education will take place in individual homes, work places, public halls and also class rooms. It will handle individuals, small groups and large audiences, depending on the situation.

o Learning and instruction will take place during any part of the day and the duration may vary from a few hours at a stretch to a fraction of an hour.

o The learner may belong to any age group, from children to pensioners.

o The medium of communication of knowledge will be a combination of the following:

i. Printed material: the press; books and correspondence instruction

ii. Lectures: class room instruction; radio and television broadcasts

iii. Audio visual aids: slides, films and television programmes

iv. Programmed instruction through computers; individualized tuition and discussion

v. Field studies; tours;

It can be reasonably expected that the above developments would have reached a significant level by 2000 AD and provide a practical and workable alternative to the formal system with which the non-formal system will co-exist and complement. It would have gained, acceptance and respectability and also recognition as an efficient and sound method of imparting knowledge and developing people.

SYSTEMS OF EVALUATION FOR 2000 AD

Prof H N Ramachandra Rao*

System of Evaluation depends on the purpose for which the examination is conducted. One may broadly classify examinations into two categories. One - University type of examinations where the object is primarily to distinguish between students-most of whom are of average ability - who deserve to get a degree and those who do not. Two - competitive examinations for recruitment to Public Services as those conducted by the UPSC, where the aim is to select a relatively small number of high calibre candidatures from a very large number of candidates of more than average ability.

The paper deals mainly with Evaluation of Candidates for recruitment to public services.

Since the attainment of Indpendence there has been a tremendous expansion of educational opportunities in our country at all levels, and the demand for higher education has increased by leaps and bounds. Further since independence, there has been an intense and pervasive concern of the State for improvement of the life of the people and their well being. Development of Science and Technology influence increasingly every aspect of our national life to a degree and extent that has no comparison with the past. An overwhelming fact is that at the close of the country, the population of the country would be nearing three times that at the time of independence.

A system of recruitment almost totally dependent on the assessment of a person's academic knowledge and skills, as distinct from ability to deal with, pressing problems of economic and social development, with people, and with noval situations cannot serve the needs of today, much less of tomorrow. Any selection method in which a written examination is not a major component is not likely to inspire public confidence in the context of a wide variation in university standards and of the educational and social background of candidates.

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* Former Member, UPSC.

It should be recognized that there are certain essential qualities which defy description in words but a 'good judge of men' can usually assess with a fair degree of reliability. An interview by a competent Board should be an indispensable element in the Evaluation process. An interview gives an opportunity of testing a person's character, competency for job and potential for growth.

In order to tackle the problem of a large number of candidates appearing for an examination, a preliminary examination of the 'objective' type is necessary. This would serve both to expand the base of recruitment and at the same time act as a filter to prevent overloading of the main examination by candidates with little chance of success.

Thus a selection process should consist of three sequential stages each making a significant and specific contribution to the total process.

It must, however, be emphasized, that it is not possible to have a process of selection which will be completely free from error or of 'wrong' selection, but the marging of error can be substantially reduced if the evaluation is dependent not on any single process but on a combination of a number of process each with its own method of merit evaluation.

Whatever may be system of evaluation valid for today, it would be surprising if a system which has been in existence for over twenty years were not susceptible to criticism and improvement. The greatest need, therefore, in for further investigation to determine the effectiveness of the tests now used, to develop new tests and ensure that its standards are neithers lax or too severe to meet the needs of 2000 AD.

SESSION—7

NATIONAL SEMINAR
ON
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BANGALORE, JANUARY 7-10, 1979

S-7

Select Technical Papers presented at Seminar

Abstract of Other Select Technical Papers

EDUCATING ENGINEER OF FUTURE IN TRADITIONAL BRANCHES OF ENGINEERING AT FIRST DEGREE AND DIPLOMA LEVEL

Prof V G Garde*

INTRODUCTION

The term "Engineer" in India means a person who holds either a degree or a diploma in engineering. The person who holds a diploma is often designated as an "Overseer", but considering his role, "Junior Engineer" would be a more appropriate designation.

The paper is written keeping civil engineering branch in view, but with a few minor modifications, it is applicable to all traditional branches of engineering.

AIM OF ENGINEERING EDUCATION

Engineering education, being professional education should be so organised that it makes the engineer at the degree as well as the diploma level suitable for fulfilling his role in the profession. These roles are :

Degree level.

(i) Role (A) : Design and research. A small number of engineers, say 10% to 15% is required for fulfilling this role in the profession.

(ii) Role (B) : Construction and maintenance.

Diploma level.

Only Role (B), viz, construction and maintenance which will naturally be at a lower level.

EXISTING FACILITIES FOR TRAINING ENGINEERS IN INDIA

India's first Prime Minister, Pt Jawaharlal Nehru, was keen on expanding technical education with a view to make available adequate technical personnel for implementing a large number of development schemes. Due to his initiative, technical education expanded rapidly - perhaps too rapidly - in India and the number of technical educational institutions and their intake soon reached the following level:

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* Chartered Engineer, Nagpur

(i) Degree Level Institutions : 143 with a total intake capacity of 22,200

(ii) Polytechnics (Diploma level) : 336 with a total intake capacity of 46,000

Due to a mild slump, the demand for technical personnel dropped and this not only stopped the opening of new institutions, but the intake to the existing institution was curtailed. As things appear at present, we are not likely to go beyond the present intake capacity for sometime.

EXISTING SYLLABUS

Degree level : The syllabus has been drafted with a view to make the person suitable for fulfilling both Role (A) as well as (B). With the advancement of engineering knowledge, role (A) has become so highly sophisticated that students gifted in that direction could be kept completely occupied by a syllabus drafted for this role. Since the syllabus is drafted for both roles, it is unsuitable for either of them. Besides this, the portion of the syllabus which is meant for role (A) is not properly understood by the majority of students.

Diploma level : Our diploma syllabus has been called -- and rightly so -- "diluted degree" syllabus. The reason is not far to seek. The diploma holder is performing a very useful role in the profession but, as compared to the degree holder, his emoluments and social status are so low, that he is thoroughly dissatisfied with his lot and is keen to secure promotion to the rank of an Assistant Engineer, as soon as possible. So instead of drafting the syllabus to make the person fit for fulfilling the role of an overseer, an effort has been made to cover as much of the degree level syllabus as possible. As already mentioned, the present day degree level syllabus is highly theoretical and mathematics-based. After working as an overseer for some time, he finds that one way to become an Assistant Engineer is to pass the professional examination conducted by the Institution of Engineers (India), etc.

MODIFICATION OF THE SYLLABUS AS A REMEDIAL MEASURE

Degree level: The author has been advocating but quite ineffectively, the starting of two separate degree courses -- one for role (A) and another for role (B). In a private communication to the author, Dr A J Morton, Professor of Mechanical Engineering at the University of Manchester, has furnished particulars about the existing three-year B Sc Honours degree course at the University and other a new four-year B Sc Honours degree course in Engineering Manufacture and Management which the University has started in October 1978. The following are some of the salient features of these courses:

Existing three year degree course in Engineering: In this, the course is common for the first two years. In the third year, the course bifurcates into the following two streams :

(i) Whitworth stream which has a bias towards the practical aspect of engineering.

(ii) Reynolds stream which has a theoretical bias.

Since this modification of the course did not fully meet the requirements of Industry, it was decided to start at a few selected centres a four-year degree course.

Four-year Degree course in Engineering Manufacture and Maintenance: The course is a combination of engineering and engineering management, and the engineering content of the course has been retained up to a high standard. To find time for teaching engineering management, the duration of the course has been increased from three years to four years. The basic knowledge of engineering imparted to the students will be applied in the Management part of the Course to problems arising specifically in the field of engineering manufacture including the design and use of machine tools, the organisation of industrial maintenance and the design and layout of factories. In addition a good deal of attention will be paid to financial and human problems. Admission to this course is mostly for students sponsored by engineering firms which also provide planned practical training to the students. The course is being run jointly by the Mechanical Engineering Department of the University, the Department of Management Sciences of the University of Manchester Institute of Science and Technology and the Manchester Business School.

PROPOSED SOLUTION FOR INDIA

The modifications to the degree courses in India will depend upon availability of facilities for training in management at the place where the engineering college is located. So we have to deal with the following two situations:

(1) Where facilities for Management Training are available :

In addition to the existing four-year BE degree course, which will be modified as indicated below, an additional four year BEEM (Bachelor of Engineering and Engineering Management) degree course should be started. An increase in the duration of the new course is not suggested, as it will be an unpopular move. With the introduction of the new degree course the existing degree course will be modified on the following lines:

The new BE course will be given a strong theoretical bias, and this would naturally mean reduction of its practical bias. The aim will be to train engineers for role (A) and the syllabus in subjects like mathematics, physics, strength of materials and theory of structures, hydraulics and fluid mechanics will be toned up. This will provide us with a good team of designers and research engineers which we certainly need, because we should not depend upon imported technology for ever.

The BEEM course will train engineers for role (B). In this course, the syllabus in the subjects which it is proposed to tone up in the new BE course will have to be toned down and the time thus saved will be devoted to the teaching of management and to field engineering. This will provide us with a team of engineers suitable for role (B).

(2) Where facilities for Management training are not available :

We should have a common course for two years after which, as at the University of Manchester, the course should bifurcate into the following two streams :

(i) Kelkar* stream for role (A).

(ii) Visvesvaraya Stream for role (B).

As time passes and more teachers of engineering management become available, the proposal under (2) will shrink and the proposal under (1) will expand until (1) becomes our standard pattern. Diploma level: The diluted degree course should be abandoned and a new course should be drafted on the lines of the BEM course but at a lower level. The course should be given a strong practical bias and considerable amount of time should be devoted to subjects like field engineering.

It will not be out of place to mention here that the syllabus for examinations conducted by the Institution of Engineers (India) and other similar bodies will have to be changed drastically and brought in line with the BEM course, so that students who pass the examinations become fit for role (B). This will make it easier for the Overseers to pass such professional examinations and while preparing for the examination they will be learning topics of real practical use. As more and more overseers become Assistant Engineers, there will be less frustration amongst the ranks of Overseers and this will attract better students to the profession and result in better over-all efficiency.

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*Dr P K Kelkar, an eminent technical educationist, was the first Director of the Indian Institute of Technology at Kanpur.

DIFFICULTIES IN BRINGING ABOUT THE CHANGE

The author realises that it will not be easy to bring about the changes suggested by him. However, the difficulty could be minimized if the changes are made gradually.

For teaching the BEEM course teachers with good field experience will be required. The bulk of present day teachers in engineering institutions can be classified under the head 'book-worms'. These teachers will have to be sent to the field for properly regulated practical training, in the beginning, and at regular intervals throughout their period of service. This would require creation of a training reserve force of teachers and this means additional funds which, I feel, the authorities will provide in the interest of efficiency.

It will be difficult to get teachers for Engineering Management. But just as there was difficulty in getting Teachers for Engineering Geology and Engineering Economics and supply followed, the demand, although with a time lag, the same thing is likely to happen with regard to teachers in Engineering Management, inspite of the fact that the demand for such teachers will be of a high order.

ABOLISHING OF DIPLOMA COURSES IN ENGINEERING

Many overseers who have bitter memories of the ill treatment received by them from graduate engineers, advocate the abolition of the diploma courses. They feel that training engineers at two different levels has created internal tension and hence disunity in the profession. The author is not in agreement with this view. He feels that the cause for tension would more or less disappear if :

(i) The designation of overseer is changed to "Junior Engineer" and he is paid the same salary as Junior Engineers are paid, as he performs the same duties.

(ii) It should be made easier for the overseer to pass the AMIE examination.

(iii) In virtue of the useful role he is playing in the profession he should be treated with greater respect by the society in general and the graduate engineer in particular.

There is another point to be taken into consideration regarding this matter. Our 336 polytechnics have, allowing for normal wastage, the capacity of providing the country annually, about 40,000 Junior Engineers. All this personnel is being absorbed. The cost of upgrading 336 polytechnics to colleges would be prohibitive and no Government would be prepared to consider such a proposal.

EVALUATION OF ENGINEERING COLLEGES AND POLYTECHNICS

Before considering how the courses outlined in the foregoing paragraphs could be effectively taught, let us consider how the existing courses are being taught in our institutions. For this the quality of the product should be a good guide. The author is not fully aware of the academic attainments of the product of our polytechnics. He has, however, a fairly good idea of our engineering graduates, and can say that there is progressive deterioration in their knowledge of the existing courses. He has exchanged ideas regarding this matter with senior engineering teachers and employers and they all feel that there is a steep decline in quality.

The author once conducted a practical examination in an Engineering College but was disappointed at the poor quality of performance by the candidates. At the end of the examination he asked the internal examiner as to what he thought of his students, and the reply was 'utterly useless'. On being asked the reason he said that the boys knew that whether they worked or not, their success was assured, so, barring the top 10%, the boys have given up working.

CAUSES OF FALLING STANDARDS

The incentive to work, for the top few students in India has always been scholarships and prizes. In the past, the remaining students used to work because of fear of failure in the examination. A situation has gradually developed in India in which the fear of failure has almost reached the vanishing point.

Student trouble has assumed alarming proportions in India. Students have been agitating for the redress of a number of grievances. Some of the grievances are legitimate but the authorities cannot redress them mostly because of lack of funds. Unfortunately, students often demand that the syllabus be toned down, qualifying standards be lowered, the choice in question papers be increased, and so on, so that they may get their degrees or diplomas without working hard. In short, they demand cheap degrees, and diplomas. This demand emanates from a few lazy and misguided students, who assume the role of leadership and the bulk of the good students follow them partly because they lack character but mostly because they are not provided with adequate protection. These student leaders get the support of unscrupulous politicians, and alongwith their tame followers, they go on rampage destroying private and public properties.

Unfortunately the Central and State Governments, in their anxiety, to pacify the students exert pressure on concerned authorities to concede the unfair demands of the students. The authorities yield because they cannot protect themselves and the property in their charge without Government help.

In buying peace at the cost of academic standards, the Government is creating a generation which will be incompetent to shoulder any responsibility.

Under these circumstances most of the Principals of Colleges feel that they must avoid student trouble and the easiest way of doing this is to ensure that there are almost no failures. So the staff is pressurised to award pass marks to every student whether he works or not. Since the students can pass without working, 90% of them do not work. If Principals are advised to take a stand they say that when there is trouble they will have to face it all by themselves and the Government will not come to their rescue. It is no use taking a stand when ultimately, one has to surrender.

REMEDIES FOR IMPROVING THE SITUATION

For improving the situation a pre-condition should be that the fear of failing undeserving students must be eliminated. If this is not done, no remedy will bring about any change for the better. As things appear at present, this condition is not likely to be satisfied. We may, however, consider what we will have to do to set matters right, if somehow the condition is satisfied.

Indian engineering students are intelligent. If we can only make them work hard, we can train really good engineers. As mentioned before, the only motivation to make most of the students work is fear of failure at the examination. If we decide the fate of the student on the result of one examination held at the end of the session, the student will work hard for a couple of months towards the end of each session. It is suggested that the failure or success of the student should be decided on the basis of results of four evaluations as indicated below :

Assuming that a paper carries 100 marks, the marks can be split up as follows:

(i)	First test with papers of one hour duration to be held about 6 weeks after the commencement of the session. Syllabus for the test : Portion of the syllabus covered from the beginning of the session upto the time of the test.	10 marks.
(ii)	Mid-sessional examination with papers of three hour duration. Syllabus : Portion of the syllabus covered from the beginning of the session upto the time of the examination.	30 marks.
(iii)	Second test with papers of one hour duration to be held about six weeks after the mid-sessional examination. Syllabus : Portion of the syllabus covered after the mid-sessional examination upto the time of the test.	10 marks.
(iv)	Sessional examination with papers of three hours duration. Syllabus : The entire syllabus covered during the session.	50 marks.
	Total :	100 marks

The first three evaluations should be entirely internal and the sessional examination should be entirely external.

If a scheme more or less on the lines indicated above is adopted and the following two precautions are taken, it will ensure hard work on the part of the students throughout the session:

(i) That there is no over-marking of the scripts.

(ii) That the teachers cover the entire syllabus.

Practice of Awarding Unduly High Marks

If this practice is not curbed and if out of the 50 marks for internal assessment the teachers award marks between, say 38 and 48, barring the top few, students will do very little work. This practice was curbed at the Malaviya Regional Engineering College, Jaipur when the author was its Principal, by fixing a ceiling on the average class marks.

There was of course no bar to an individual student being awarded even 100% marks, but if the ceiling on average class marks fixed by the Principal was exceeded the University of Rajasthan had authorised him to moderate the marks awarded by the internal evaluator. It may be mentioned here that there was no objection either from the staff or the students to the level of the ceiling fixed by the author. The ceiling was, of course, subject to review at periodical intervals. It may be noted that the scheme worked smoothly and the author had no occasion to moderate the marks awarded by a teacher.

The Practice of Not Teaching the Entire Syllabus

If the assessment is entirely internal, some teachers do not teach the difficult portion of the syllabus and confine the question paper to what they have taught. The entirely external sessional examination acts as a deterrent to this mal practice.

The assessment at the Indian Institute of Technology is entirely internal without any precaution against unduly high marking. The result was the type of product already described.

CONCLUSION

This paper leads to the following main conclusions:

(i) Our syllabi for the degree and diploma courses do not prepare the students to properly fulfill their roles in the profession. Suggestions have been made for modifying the syllabi. So the remedy suggested is mostly the concern of the academician.

(ii) Rapidly falling standards are mostly due to over-marking and teachers not teaching the entire syllabus. Remedies against over-marking have been suggested. It has also been suggested that if we have mixed internal and external assessment, the teachers are likely to cover the entire syllabus. A note of caution has been sounded viz. the adoption of the suggested remedies may lead to student unrest, so full Government support should be sought before implementing the scheme.

ACKNOWLEDGEMENT

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(v)	Prof V S Mokashi, Professor of Applied Mechanics.	
(vi)	Prof P R Bhave, Professor of Civil Engineering.	

SURVEYING EDUCATION

G S Kumar*

INTRODUCTION

The scientific, technological and social changes have brought in its train rapid transformations in the environment around us throwing up new challenges to be faced by the engineers. An engineer therefore has a pivotal role to play in all major developmental programmes in a country. Exploitation of the natural resources with minimum degradation of the environment is today's major task faced by the engineers. Thus, an accurate and efficient survey of the land and its environment assumes great importance. "Surveying Engineers" are necessary to prepare fast and uptodate maps for efficient land and environmental management.

REQUIREMENT OF SURVEYORS

There are many organizations under the State and Central government and the private sector carrying out surveying as a part or main job like Survey of India, State Survey and Land Records Departments, Public Works Departments, Irrigation Departments, Survey and Investigation Organisations, Highway Departments, Town Planning Departments, Civil Engineering Colleges and Polytechnics, Geological Survey of India, Mining Organisations, Central Water Commission, National Atlas Organisation, ONGC, Electricity Boards, Public Health Departments, Municipal Organisations, etc.

The main requirement of surveyors in the above mentioned organizations can be considered broadly at two levels - Management and the Technician level. Estimated requirement of Diploma level surveyors works out to about 300 and that at Graduate level and above to about 80 per year in the country.

PRESENT CONDITIONS OF SURVEYING EDUCATION

Survey of India, the national surveying organisation, whose main job is land surveying, recruits the staff and imparts them training at the Survey Training Institute at Hyderabad in modern surveying techniques with good practical and theoretical coverage. In most of the other organisations, a sort of inservice training facilities exist.

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In the educational institutes, surveying is taught as part of civil engineering in Polytechnics and Engineering Colleges and unfortunately has generally been a neglected subject. According to an unpublished report compiled by the author on 'Surveying education in India', surveying generally forms about 1/12th of the civil engineering course and it is less than 1/6th of the period spent by an engineering/mathematics graduate trainee in Survey of India. There is a general feeling in the colleges that subjects like Structures, Soil Mechanics etc are given preference to surveying. It is also a fact that civil engineers generally show preference to lucrative fields like Irrigation, Buildings, Public Health, Highways etc as compared to surveying which is considered to be a dry and drab field. Another reason for the neglect of this subject is that the lecturers in civil engineering institutions generally lack practical experience in the field of surveying. The students under them are therefore unlikely to develop proper concepts about the fundamental aspects of surveying. Lack of (i) trained and experienced staff (ii) rigorous field training facilities (iii) modern surveying instruments and (iv) future prospects are the main factors contributing to the neglect of this subject in the engineering institutions. Even the annual survey camps are not taken seriously and are often considered as outings by the students.

SURVEYING ENGINEERS

In a country like India which has embarked upon ambitious plans of development in various fields, there is a great need of "Surveying Engineers" to carry out survey of land and its environment to help planners and engineers. With the natural resources fast depleting and the population and needs increasing there is an urgent need to evolve scientific methods of efficient utilization of the available resources. For this purpose a continuous and efficient system of evaluation of the resources is necessary. It is in this vital area of development that the knowledge of surveying is necessary. Thus a surveying engineer is going to play a very important role in the years to come by helping the planners and engineers in making proper utilisation of the resources through efficient environmental management. It is also the responsibility of the surveying engineers to provide the data about earth and its environment to the environmental managers/planners so that they can make a continuous assessment of the treads of development and pattern of environmental degradation. The modern scientific tools like aerial photography and other remote sensing techniques should be made use of by a surveying engineer to produce maps showing uptodate and accurate information about water resources, vegetation, urbanization, rural conditions, soil erosion patterns, floods, forest, pollution, etc. Surveying engineers are therefore to be prepared to meet this challenging task affecting the present and the future generations.

COMPREHENSIVE COURSES IN SURVEYING

Most of the advanced countries having realised the importance of surveying in national developmental activities have introduced comprehensive courses in surveying many years back. In Central Europe and East European countries like Germany, Austria, Switzerland, Holland, Poland, Czechoslovakia, Hungary, Yogoslavia, Finland and Russia, there are degree courses in surveying usually of 5 years duration besides other higher level courses. In Warsaw University, Faculty of Cartography has 12 chairs, over 80 members of academic and scientific staff and 470 students. In the Institute of Moscow, for training Geodetic and Cartography Engineers, there are 4 Faculties of Geodetic, Photogrammetric, Cartography and Optical Mechanical with 22 professors and 67 Assistant professors. They have comprehensive courses of 5 years duration for the degree level course in surveying. In China, at the Institute of Geodesy and Cartography, there are 2,500 students, 246 staff members of whom 17 were professors as far back as in 1958. In Canada and Australia also there are comprehensive courses in surveying. In Africa, degree courses in surveying were introduced in 1930s ! (1)

Whereas in India the surveying jobs in most of the organisations are being carried out by persons not fully qualified for the job. This situation is sought to be justified by the organisations on the plea that qualified surveyors are not available. The educational institutions (Engineering colleges) do not seem to introduce surveying courses on the ground that there is no demand for them. It is an undisputable fact that qualified surveyors are required in various organisations in the country. Engineering colleges should therefore take the initiative to introduce courses in surveying and help the nation to bridge a very vital gap in engineering education.

SYLLABUS OF SURVEYING COURSES

The aim of surveying education like education in any other scientific/engineering field, should be to prepare the engineer for multi-functional duties. The main functions of an engineer involve, Investigation, Research, Teaching, Direction, Supervision, Organisation, Control of Production and Execution. Considering the important role of surveyors in providing an uptodate inventory of the available natural resources to the planners, engineers and others, it is necessary that a surveying engineer should be taught the basic elements of all the connected subjects with sufficient emphasis on practical aspects and human interface. Management being one of the essential functions of an engineer should form part of engineering education. In the prevalent conditions in our country, one cannot ignore the falling moral standards in general and the reputation of the engineers in specific. It is therefore very essential that a proper attitude towards "moral values" is developed amongst students of engineering so that they uphold the true values of this noble profession in their future careers.

The course can be organised at three levels - (1) Diploma (2) Graduate and (3) Postgraduate and above.

Diploma Level

Usually the engineering diploma is of 3 years duration out of which the 1st year is common for all engineering students. The students choosing 'survey engineering' should branch off after 1st year and should continue for 2 years for 'Diploma in surveying'. The present syllabus of surveying followed in the Polytechnics for civil engineering students should be modified to include the essential aspects of surveying. Annexure I gives the main topics of the suggested syllabus for Diploma course in surveying. Based on the allocation of periods for theory and practicals, it is possible to work out the detailed syllabus taking into consideration the syllabus being followed at the Survey Training Institute of Survey of India at Hyderabad.

Degree Level

Most of the Universities/colleges have 5-year course in engineering with first 2 years of study being common to all students. Like other branches of engineering, surveying course should also be for 3 years. The existing syllabus of surveying should be modified to include all the essential topics. The topics will be more or less same as that for Diploma level students but with more advanced coverage. However, the main topics of the proposed syllabus showing the periods against them are given in Annexure II.

Post-Graduate Level

The field of surveying actually includes specific fields like Topographical surveying, Large scale and engineering surveying, cadastral surveying, cartography, geodesy, photogrammetry, aerial photography, remote sensing techniques and their applications in land surveying. Post Graduate courses can be organised in the above subjects. In USA, USSR and some European countries, regular Post-graduate courses in geodesy, cartography and photogrammetry are being run since many years. A few years back, in Survey of India also, advanced courses (Post graduate level) in Geodesy and Photogrammetry have been introduced.

CONCLUSION

The earth and its environment is undergoing rapid changes as a consequence of developmental activity in the country. To keep a proper check on these changes and also to make the proper use of the available natural and other resources, the planners and engineers need accurate and upto-date data. This job can be efficiently handled by surveying engineers. The existing educational institutes do not have the necessary facilities to train professional surveyors required in various organisations in the country. It is therefore hightime that comprehensive courses in land surveying are introduced in our country. Complete details of the syllabus for the courses can be worked out in consultation with Survey Training Institute, Survey of India, Hyderabad. To make these courses purposeful and beneficial to the country it will be essential to make it obligatory for all organizations engaged partly or fully in surveying to employ only qualified 'Surveying engineers' in their organizations. The Institution of Engineers (India) in association with the Institution of Surveyors of India can take a lead in this respect. The introduction of these comprehensive courses in surveying will usher in a new phase in the field of engineering science which will go a long way in creating a team of Surveying engineers required in this country.

REFERENCE

1 G S Kumar. Surveying Education and Professional Surveyors - Brochure of the Institution of Surveyors on the Symposium on Surveying, Land Economy and Surveying Education - September, 1974, p 10.

ANNEXURE I

SUGGESTED TOPICS OF SYLLABUS FOR DIPLOMA COURSE IN "SURVEY ENGINEERING".

Note :- (1) 1st year's syllabus is considered common with other engineering courses and syllabus for final two years is suggested.

(2) 1600 periods of 45 minutes duration are assumed to be available in a year.

(3) Considering that a Diploma surveyor is expected to do more of practical work in his career, the practical/tutorial part is allocated 60% of the total periods.

MAIN TOPIC	PERIODS		
	THEORY	PRACTICALS & TUTORIALS	TOTAL
Fundamentals of Surveying	200	100	300
Topographical Surveying	200	400	600
Geodesy	150	150	300
Cartography	100	300	400
Photogrammetry	200	300	500
Cadastral Surveying	100	100	200
Engineering Surveying	100	200	300
Aerial Photography & other Remote Sensing Techniques	50	50	100
Surveying Computations	100	200	300
Other Surveys	100	100	200
TOTAL :	1300	1900	3200

ANNEXURE II

SUGGESTED TOPICS OF SYLLABUS FOR DEGREE COURSE IN "SURVEY ENGINEERING".

Note :- (1) Considering the first two years to be common with other courses of engineering, syllabus for the final 3 years has been suggested.

(2) 1600 periods of 45 minutes duration are assumed to be available in a year.

(3) 50% of practicals are considered sufficient.

MAIN TOPIC	PERIODS		
	THEORY	PRACTICALS & TUTORIALS	TOTAL
Fundamental Surveying	300	200	500
Topographical Surveying	350	600	950
Geodesy	250	250	500
Cartography	300	300	600
Photogrammetry	400	400	800
Cadastral Surveying	150	150	300
Engineering Surveying	150	200	350
Aerial Photography & other Remote Sensing Techniques	200	100	300
Planning, Management & Computer techniques	150	100	250
Hydrographic, Building & Quantity and Valuation Surveying	150	100	250
TOTAL :	2400	2400	4800

IMPARTING DESIRED KNOWLEDGE IN ENGINEERING EDUCATION

Prof G R Damodaran*
Prof R Subbayyan**
Dr M C Vaithilingam ***

INTRODUCTION

Technical education can be considered in totality as a system whose output is the technical man-power for a region or nation, the input being effective teaching man-power, well-equipped laboratories, libraries, industrial training centres and the like which in turn require considerable investment. The technical education like any other system should be sensitive to cope with the changing needs of technical man-power. The aim of the education should be such that it uses the man-power available in a country like ours as well as the resources; otherwise, the impact and importance of such an education will not be felt by industry and by a majority of the population who in turn support the existence and development of such systems. The education should also incorporate in itself a futuristic notion in that the engineers of to-day should be able to face the technological challenges of the future, because a fresh engineer will be in the field for at least another three decades. System theory techniques have been applied to several aspects of engineering education[1-3]. In this paper the problem of imparting desired technical knowledge to a student is discussed. The problem is analysed under the frame work of system theory and certain important observations are brought out and their significance emphasized.

KNOWLEDGE GROWTH OF STUDENT

The knowledge growth of a student during a semester in a particular discipline is modelled, considering the interaction among the subjects. The knowledge x_i of a student in a subject i is modelled as

$$x_i = a_1x_1 + a_2x_2 + \dots a_ix_i + \dots + a_nx_n + b_1u_1 + b_2u_2 + \dots + b_iu_i + .. + b_nu_n + f_i \text{ (individual effort)} \qquad (1)$$

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where it is assumed that the rate of growth of x_i is proportional to x_i, the proportionality factor being a_i. The knowledge growth x_i in a subject i depends also on the student's knowledge in other subjects x_j, $j \neq i$. For example, when i happens to be pertaining to electrical machines, specially linear electrical machines, a good knowledge in the subject j, electromagnetic field theory, will enhance the understanding of the subject i and hence, the knowledge growth in the subject i. The factor a_j should reflect this situation among other things, if the model is meaningful.

The input component u_i is the input corresponding to a particular subject i. It is again assumed that the inputs corresponding to the subjects $j \neq i$, also contribute to the knowledge growth in the subject i. In addition to the input by way of instruction from the faculty, the student can generate his own input to his knowledge growth by way of self-study, discussion and experimental observation. The knowledge x_i encompasses both analytical and practical abilities.

At this stage certain observations which bring out the limitations of the model are in order. The model is of such a form that it implies that x_i responds without delay with respect to u_i, $i = 1,2,..,n$; this is not true in practice. Further, u_i is not continuous; it is at the most piecewise continuous. Other questions pertaining to the model are the number of subjects n one is to study and their choice in a given semester and the nature of the parameters a_i and b_i. It is to be noted that when $u_i = 0$, $i = 1,2,...,n$, x_i changes depending on f_i. Of course, the realistic model is not deterministic.

The initial condition to equation (1) can be taken to be the knowledge of the student in the subject i at the time of entry to a given semester.

If the number of subjects to be studied in a semester is n, the knowledge of the student in the n subjects can be represented by the vector $x = [x_1 \; x_2 \ldots x_n]'$ and the growth rate of x can be expressed as

$$\dot{x} = Ax + Bu + f \qquad (2)$$

where A is an $(n \times n)$ matrix, B is an $(n \times n)$ matrix and f is an n vector. Assuming that self learning ability f_i in a particular subject i is proportional to x_i, equation (2) can be expressed as

$$\dot{x} = \tilde{A}x + Bu \tag{3}$$

The knowledge state of a student can be expressed as

$$y = Cx \tag{4}$$

where C is an identity matrix.

The desired growth of knowledge y_{di} for a given subject i may be displayed as in Figure 1, during a semester. The problem is to determine u and more importantly its structure in the present context such that

$$y \cong y_d \tag{5}$$

where y_d denotes the vector of desired growth of knowledge in all the n subjects. It is now possible that this problem is brought within the frame work of tracking problem which is briefly presented in the Appendix.

OBSERVATION:

Recalling the results of tracking problem given in the Appendix, it is seen that the desired knowledge growth y_d and its terminal value at time T, determines g (refer Appendix) which forms one component of input u, independent of state of the system. The command z (refer Appendix) can be considered to correspond with the detailed syllabus as well as its rate of coverage; g can be considered to correspond with the instruction in the form of lectures and laboratory assignments. This means that before an instruction begins, what is desired from a student is to be definitively fixed and this aspect should be reflected in framing the syllabus for a given subject.

The other component of the input which depends on the state, namely $K_2 x(t)$ (refer Appendix) can be considered to correspond with the measurement of the knowledge level of a student. Hence, the knowledge growth of a student in fulfilling the requirements of the syllabus can be modelled as shown in Fig 2.

It is noted from Fig A.1, that the structure of the system which generates g is a function of the matrices A,B among other things; in other words, it is a function of the elements of the system which tracks. This aspect, when translated to the problem of education, brings out clearly the fact that the input component corresponding to g, should take into account the analytical and practical ability status of a student, undergoing instruction in a particular subject.

NEED FOR INDUSTRIAL EXPERTISE ON THE PART OF INSTRUCTOR

If one considers the system which generates one component g_i of g as corresponding to an instructor in-charge of a particular subject i, and the desired growth of knowledge, namely the specified syllabus and its coverage as corresponding to the input to the instructor, then the instructor can correctly translate the syllabus contents as input to the students, only if he is in tune with the requirements and expectations of the syllabus. If the syllabus calls for a detailed exposition of a product manufacture or the design of an electronic circuit for a special environment or the relevance of a particular theory to practical applications, unless the instructor is familiar with such situations, one can easily see that his output to students cannot be as desired. This means that the instructor cannot reflect problems and challenges arising from the acquaintance with practising engineers whose problems have real-world origin. Such a sort of instruction devoid of the necessary practical bearing happens when universities employ graduates who do not have practical training or industrial experience and this unhealthy situation is illustrated in Fig 3.

IMPORTANCE AND ROLE OF FEEDBACK

As can be seen from the results of tracking problem the control input u^* contains as one of its components, the feedback of all the states of the system. This means that for effective imparting of knowledge as desired, the input to the students should be modified as dictated by the feedback; very clearly, the knowledge state of students should first be measured and fed back by appropriate techniques by the instructor. Further, from equation (A.4), it is noted that the input component which depends upon the feedback, requires the feedback of all the components of the state, $x_1, x_2, \ldots, x_n$. This again implies that the instructor in-charge of the subject i, should measure the present knowledge state of the student in all subjects including i and should modify his input for the subject i based on the measurement. Normally, an instructor in-charge of the subject i, say, Electromagnetic Field Theory, may not be bothered about the knowledge level of the students in other subjects. But, the solution of the tracking problem demands that the instructor should modify his input for a subject depending on the measured knowledge level of the students in other subjects as well. For example, if the knowledge of students in certain topics of mathematics is not sufficient, then the students may not cope up with the instruction in certain subjects, say, electromagnetic field theory. This means that before the instruction begins in electromagnetic field theory, the instructor should have a measure of the knowledge level of the students in the topics of mathematics, relevant to field theory. This measurement may be done by the instructor by oral questions directed to the students; or the necessary information to this effect may be provided to the instructor by the faculty of mathematics. This aspect brings out clearly the necessity of coordination and information interchange among the instructors handling the subjects for a particular class. Of course, the 'coupledness' of one subject to the other, exists not to the same degree for all subjects. For example, sufficient (or insufficient) knowledge in Applied Mechanics does not contribute in any big way to the understanding of field theory or vice-versa.

As for the measurement and feedback of student's knowledge state is concerned, they should be done without delay. It is clear that in control systems, controlling physical operating systems, any delay in the feedback of information will endanger the stability of the system; in other words, the delay will result in widening the deviation between the desired and actual state of the system with respect to time. The same conclusion applies to the learning environment also. If the student lags behind in learning, he will not cope with or track further developments in the subject and this situation will pull down his confidence; hence, the necessity of appropriate correcting input, based on the measured information.

The feedback of student's knowledge status should have impact on the students from several points of view. It should indicate to him his present level of knowledge in relation to the desired level expected of him. It should also indicate to the student the direction he should take or pursue to improve his situation. All these aspects should reflect in the instructor's observations and comments explaining the cause of an incorrect approach to solve a particular problem as well as the correct approaches. In this connection, mention may be made of the "Continuous Assessment Record" to be maintained individually by the students of PSG College of Technology (Autonomous and affiliated to the University of Madras). One sample page of the record is shown in Fig 4. Each page of the record is meant for a particular subject; the instructor in charge of a particular subject has to enter the marks obtained by a student in tests/assignments as well as the date and month of tests/assignments. The physical possession of such a record by the students individually has a psychological impact on them, reminding them more or less continuously their academic status.

CONCLUSION AND DISCUSSION

The significant aspects which assume importance in imparting desired knowledge to students are discussed in this paper by modelling the knowledge growth of a student in a semester and then treating the problem of knowledge growth within the framework of tracking problem. The fact that, in general, knowledge growth in one subject is influenced by the knowledge level in other subjects is made clear. This illustrates the need for phasing the subjects of study in the respective semesters. In this connection, the need for an effective coordination and information interchange among the instructors in-charge of a class is emphasized. The influence and the need of industrial experience on the part of the instructor in enhancing the student's appreciation to practical problems is brought out. The need and role of timely measurement and feedback of knowledge levels are reemphasized.

This paper essentially has discussed the matching or aligning the knowledge growth with respect to the desired rate. But the more important question is regarding the desired knowledge growth and its level at the completion of a course or programme. The specification on y_d is to be done by futuristic study of the industrial growth and techniques as well as the scientific and analytical developments.

What has been said for matching the knowledge growth, will equally apply for matching the output of technical institutions with the needs of the future, considering the fact that the present-day institutions are preparing the senior engineers of 2000 A.D. This may be made possible by conducting a survey on engineering graduates employed in different channels, say, purchasing, sales, servicing, operation and maintenance, research, design and development and projecting this survey into the future, so that the effective and resource-consuming engineering education turns out to be appropriately utilised for which it has been intended.

REFERENCES

1 G R Damodaran and G P Rao. 'Employment Optimization in a System of Technical Education via Optimal Allocation', International Journal of Systems Science, Vol 5, 1974, p 21-27.

2 N K Sinha and C D di Cenzo. 'Stochastic Models for an Educational System', International Journal of Systems Science, Vol 6, 1975, p 1001-1007.

3 H W Farris. 'University - Industry Relations- Needs and Methods', IEEE Transactions on Education, Vol E-10, 1967, p 193-197.

4 M Athans and P L Falb. Optimal Control: An Introduction to the Theory and Practice, (book), First Edition, McGraw Hill Inc, New York, 1966, p 793-801.

APPENDIX

REVIEW OF TRACKING PROBLEM

The important results of tracking problem are presented to an extent sufficient for the discussion. Consider a linear dynamical system with state x (t), control input u (t) and the output y(t). The system equations are

$$\begin{aligned} \dot{x} &= Ax + Bu \\ y &= Cx \end{aligned} \qquad (A.1)$$

where x is an n vector, u is an m vector and y is a p vector. In general, the matrices A, B and C are time-varying. The objective of the tracking is to control the system (A.1), so that the output vector y is near to the specified or desired p vector z (t). Let the error vector e (t) be defined as

$$e = z - y \qquad (A.2)$$

The problem is to determine u(t) so that the error e(t) is 'small' in such a way as to minimise the cost functional

$$J = \tfrac{1}{2} \langle e(T), Fe(T) \rangle + \tfrac{1}{2} \int_{t_o}^{T} \left[\langle e, Qe \rangle + \langle u, Ru \rangle \right] dt \qquad (A.3)$$

where

T is the terminal time specified,

F is a constant (p x p) positive semidefinite matrix

Q is an (n x n) positive semidefinite matrix and

R is an (m x m) positive definite matrix.

The optimal control u* which minimises J is given by [4]

$$u^* = R^{-1} B' (g - Kx) = K_1 g - K_2 x \qquad (A.4)$$

where K is the solution of the Riccati type matrix differential equation

$$\dot{K} = -KA - A'K + KBR^{-1} B'K - C'QC \qquad (A.5)$$

with the boundary condition

$$K(T) = C'(T)FC(T) \tag{A.6}$$

The vector g in equation (A.4) is the solution of the linear differential equation

$$\dot{g} = -(A - BR^{-1}B'K)'g - C'Qz \tag{A.7a}$$

with the boundary condition

$$g(T) = C'(T)Fz(T) \tag{A.7b}$$

It is to be noted that the control u^* requires the feedback of all the components of the state x as well as the components of g; g in turn is solved from equation (A.7) wherein z can be considered as the forcing function. From equation (A.7) it is clear that in order to determine the present value of g, one must know all the future values of the desired output $z(\tau)$ for all $\tau \in [t, T]$. This means that the present value of the optimal control depends upon the future and this is an important observation. The simulation of the system which produces g is shown in Figure A.1. The simulation of the optimal tracking system is shown in Figure A.2.

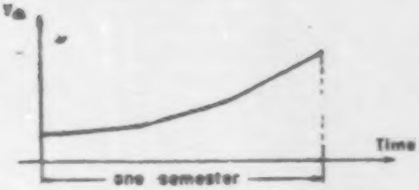


Fig. : 1 Desired Growth of Knowledge.

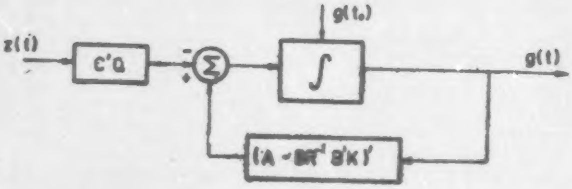

z(t)
C'Q
Σ
g(t₀)
$\int$
g(t)
(A − BR⁻¹ B'K)'

Fig. : A. 1. Simulation of the System to Generate g(t)

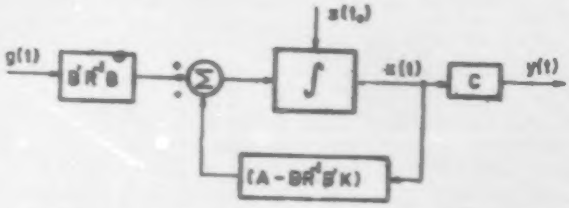

g(t)
B'R⁻¹B
Σ
x(t₀)
$\int$
x(t)
C
y(t)
(A − BR⁻¹B'K)

Fig. : A. 2. Simulation of the Optimal Tracking System.

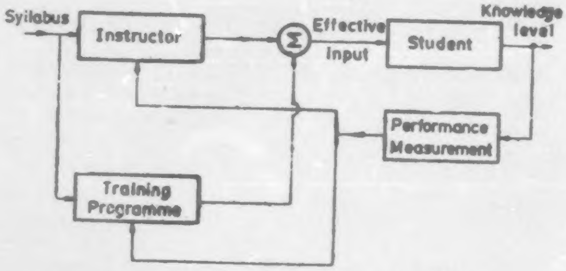

Syllabus
Instructor
Σ
Effective
Input
Student
Knowledge
level
Performance
Measurement
Training
Programme

Fig. : 2. Information flow and Feedback in Education.

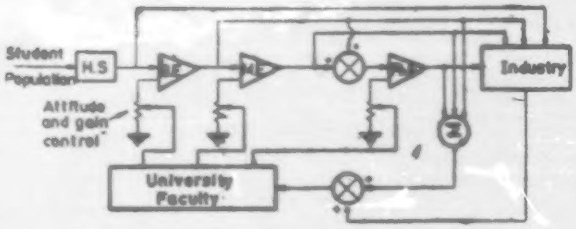
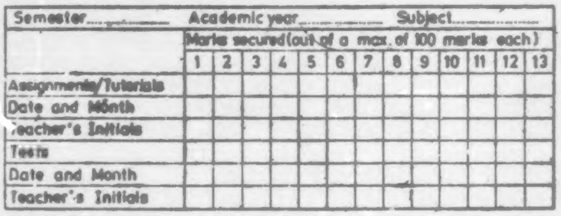

Student
Population
H.S
Industry
Attitude
and gain
control
University
Faculty
Σ

Fig. : 3. Unhealthy Composition of University Faculty.



Semester........	Academic year........						Subject........						
	Marks secured (out of a max. of 100 marks each)												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Assignments/Tutorials													
Date and Month													
Teacher's Initials													
Tests													
Date and Month													
Teacher's Initials													

Fig. : 4. Sample Page of Continuous Assessment Record.

EDUCATING ENGINEERS OF FUTURE IN TRADITIONAL BRANCHES OF ENGINEERING

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N V Vasani**

INTRODUCTION

It is not known how long 'traditional' can remain truly traditional, particularly in the context of engineering content and competence. Each traditional engineering branch, for that matter, has not only evolved over the years, but also almost metamorphosed itself into different magnitude, form, scope and even professional status. These changes are injected on account of development and needs felt from time to time. If it is really possible to extrapolate realistically the directions of development of technology and projections of needs in our frame of reference it may give a fair guidance to set our hands in moulding scheme and pattern of engineering education at the turn of the present century. In this futuristic exercise, a drama for future, its art and craft, tastes and interests of the audience, style, theme and stage of that future time have to be considered to-day. This is not only an impossible task but an unavoidable one.

LOOKING BACK

Engineering has been defined as the professional art of applying science to the optimum conversion of natural resources to the benefit of man[1]. And an Engineer is a person qualified by aptitude, training, and experience to perform engineering functions. Functions of Engineering are research and development, design, construction, production, industrial, operation and maintenance, application and sales, and management. To this list may be added consulting and teaching. In fact, consulting is an engineering activity which cuts across the spectrum of functions. Also, engineering teaching is another activity which cannot be restricted to a single function. When one considers engineering, engineer and engineering functions today and those of past it can be seen that they have had the same significance all the time and there is no reason why they should not continue to have same degree of significance in future. In other words, since Industrial Revolution and inception of formal engineering education these three dimensions - namely, engineering, engineer and engineering functions - have remained unchanged. Classical branches of engineering profession have over the years, traditionally developed around these three dimensions. What appears as a change is generally a shift in accent on one thing or the other. A generally well trained engineer can meet with such exigencies of time-variant shifts on accent without being much out-dated and without feeling himself unequal to the task.

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Engineering is largely concerned with the mobilization of resources to satisfy society's needs[2]. These needs and particularly the availability of the resources to meet with these needs, are rapidly changing and therefore the tasks facing the next generation of engineers will be indeed very different from those of today. Also, the people in a developing country expect the benefits of technology without the disadvantages of resource depletion, environmental pollution, noise and stress. But, when one considers the roles played by an engineer since Industrial Revolution, it is easy to realize that the tasks facing him have always changed, from decade to decade, sometimes when new problems had to be dealt with existing technology and at times when old problems had to be re-attacked with new technology. In either situation, engineer had proved his mantle and it was not felt necessary to tailor a scheme of education and training much in advance as an anticipative exercise. This was possible because the traditional branches could carry many off-shoots which were accommodated in curriculum contents in gradual manner. There are no quantum-jumps in such situation. What passes as changes are essentially structural changes and not major deviations steered away from the traditionals. Addition of new branches on account of space research and computers does not undermine the status of traditional branches.

LOOKING AHEAD

The traditional branches in engineering can be listed as Civil Engineering, Mechanical Engineering, Electrical Engineering, Mineral Engineering, Industrial Engineering, Chemical Engineering and Aeronautical Engineering. To this may be added Agricultural, Acoustical, Architectural, Geological, Marine, Military, Nuclear, Ordnance etc. Each of these branches has several sub-branches added to it depending on unified body of knowledge and application of speciality within a branch.

Civil Engineering had, in its early stage, and even upto fifties, been a matter of theory catching up with practice. Even then, new technical problems like designing huge radio antennas with tilt and rotation, developing of materials with strength of high temperatures and structures for radiation-protection, conceiving new architectural shapes in construction and extensive use of computers could be handled by the engineers who were not particularly trained for these tasks.

The work of the mechanical engineer is all embracing and touches every aspect of all engineering activities. Technology-triggered industrial revolution saw the mechanical engineer's skill in converting material and energy into desirable things. This will continue to inspire him to undertake new tasks of alternative energy sources, optimization of resource utilization, development in mass transportation and designing comfortable working and living environment.

It would take many years for electrical engineers to exploit fully the potentialities of electric and electronic devices. In early sixties a conservative prediction was made that within a short span of ten years there would be more new developments than in the 60 years since the first development of water power at Niagara and Marconi's work in wireless telegraphy. This prediction has come very much true.

Without further elaborating the specific achievements in different branches on a historical time-scale, it would now be possible to appreciate that each traditional branch with the vigour of a live branch and flexibility of a green and growing tree, has been able to rise above all expectations. This is because engineer is a continuous learner, and while using technology he also generates new ideas which give birth to new technology or technological devices. It is his strong point that he picks up the thread at the end which is handed over to him and gradually - not in an abrupt manner, - adds his experience and expertise and then passes on to the next. In short, nothing radical needs to be done for traditional branches for preparing engineers for 2000 A.D. These branches already have deep roots and good growth. What is necessary is to consider how new approach to technology and not approach to new technology, will demand new answers from traditional branches. This brings us to planning for engineering education and considerations of appropriate technology.

NEW LOOK

Alvin Toffler[3] while writing on the new educational revolution comments : "The technology of tomorrow requires not millions of lightly lettered men, ready to work in unison at endlessly repeated jobs, it requires not men who take orders in unblinking fashion, aware that the price of bread is mechanical submission to authority, but men who can make critical judgments, who can weave their way through novel environments, who are quick to spot new relationships in the rapidly changing reality. It requires men who, in C P Snow's compelling term, have the future in their bones." This will need in terms of engineering curriculum a clear re-definition of relationship of engineering education with social sciences. For historical appreciation, realistic socio-economic implications and value judgements in involvement of technology, the study of social sciences will have a role to play in training the engineer of future. It will indeed require good deal of innovative effort in this decade on the part of engineer educationists how best to integrate the study of social sciences in engineering education. Leaving aside a debate of how much to teach of what of various social sciences, what is more urgent is to so integrate the studies as to provide an engineering student a consciousness of social obligations, societal needs and aspirations, common human failings and perspective of future at least in a limited way[4]. Study of social science not only enriches the personality of the engineer but also develops his sensitivity to aspirations, expectations, needs and life-style of the society. Besides, it equips him to handle organizational and human problems relating to his own profession more scientifically and adequately. Engineer of future will have to be trained to curb consciously and actively the inherent dehumanizing traits of technology as symptomizing since a few decades.

Howard R Bowen[5] had raised a few questions in relation to planning of higher education. They are very much relevant to the engineering education. Those who set their minds on the engineering education for future, particularly in traditional branches, will have to recognize the merits and limitations of the following :

> .. Does the economy require a more or less fixed (qualitatively) inventory of occupational skills at each stage in its development ?

The answer is affirmative if the accent is on encouraging appropriate technology deployed for achieving basic human needs and moderate standard of living, rather than frittering of resources with wide variations in standards of living.

> .. Is it possible to predict the character of economy and its skill requirements for periods long enough to be pertinent to educational planning ?

The answer is again affirmative. This is because for the socialist and the developing nations the blue-print of society is all drawn out and all the resources are to be directed towards realizing it. Hence, the man-power principle, and not the free-choice principle, will be operative.

CONCLUSION

It has been attempted here to show that the traditional branches have deep roots and they are capable of meeting with any challenge of the future. No immediate radical changes are foreseen in near future. Content updating with the growth in knowledge can be done in gradual manner. Intensive need, if any, can be taken care of by ad-hoc continuing education programmes. The greatest efforts for future will be required in the area of integrating social sciences in engineering curriculum, man-power planning and emphasis on appropriate technology.

REFERENCES

1 Ralph J Smith. Engineering as a Career, McGraw Hill Book Company, Inc, 1962.

2 K A Tubman and J S Lewis. Preparing Professional Engineers for 2000 AD, The International Journal of Mechanical Engineering Education, Introducing the New Style, IJMEE, 1977, p 1.

3 Alvin Toffler. Future Shock, Bantam Books, 1974, p 403.

4 Mechanical Engineering Education Development Centre, Role of Social Sciences in Engineering Education, Proceedings of the Seminar, August 1977 (I I T, Madras).

5 Howard R Bowen Universities and Manpower Needs, The American Review, Winter 1977, p 87.

CONTINUING EDUCATION FOR MECHANICAL ENGINEERS OF FUTURE

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With the rapid advancement in the technology, one has to keep up with the recent developments. The space laboratory and harnessing of Solar and other non-conventional energies are some of the distinct achievements of the near future. To cope with the rapid developments, the mechanical engineers of the future have to be trained in a befitting manner. Continuing Education is a continuous process in which one learns while he is earning also. In other words continuous Education should be for continuous adaptability. Since the operation and maintenance of plant and machinery is of crucial importance for optimal utilization of production capacities in industry, continuing education for this service should not be considered as mere routine and rated as second class activity. The continuing education should be considered as important as research, design and production activity in an industry. In a socialistic pattern of society every one should have an opportunity to reach the top of the ladder and continuing education is one of such means through which he gets it fulfilled.

A mechanical engineering graduate, who has graduated twenty five years ago, has read much of steam engines and very little of steam turbines, has never heard of super-critical pressure boilers, the numerical controlled machines were not heared by him and the hydraulic copying machines were just introduced. If we see the picture today, steam engines have been kept in technical museums, numerical controlled machines are the back bone of manufacturing process and high pressure boilers are the order of the day. As such the mechanical engineer of twenty five years standing finds himself in a very discomfortable position. He knows very little about all these new developments until he keeps his knowledge up-to-date and has worked on them. This is possible through special short term courses in which a comprehensive picture of the concerned topics is given. The connected engineers should be detailed for such trainings and it will be useful that such short term refresher courses should be made compulsory. The increments may be linked with such courses.

Such courses should be held after a regular interval of six months and after two years advanced courses on the same topics be held. The visits to the works where the advanced technologies are being used will be of much use to the working engineers. It has now been established that the continuing education for working engineers is the need of the day.

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One of the difficulties could be to motivate the working engineers for such up-dating courses.

The teachers of engineering colleges and Polytechnics should have the latest knowledge of the subject. Re-training is essential since new areas would continuously emerge and also to meet the country's technological needs. Most of the teachers try for the same through technical journals and new books. Even then Summer Schools for them on all new topics should be a regular feature. The Summer Schools could be industry-oriented where such industries exist. The duration of the Summer Schools may vary from two weeks to four weeks. Laboratory work and actual work by the participants may be stressed to give an insight in the subject. New topics with application to the industry should be introduced in Summer Schools. For mechanical engineers, topics like Industrial electronics applied to machines, special machine tool technology like- numerically controlled machines, hydraulic copying machine tools etc could be chosen. Topics such as high pressure boilers with special reference to big capacity boilers and big capacity high pressure steam turbines could be included. They could be run in collaboration with industries manufacturing these items. Such topics on industrial engineering like modern management technique of PERT and CPM, statistical quality control, etc may also be included. Erection of machines and maintenance of plant and machinery may also find a suitable place in the list to be organized for the mechanical engineers.

Engineers working in the industries may be asked to attend the Summer Schools. Short-term refreshers course will be more useful to the engineers engaged in industries. For example the behaviour of new materials used in high pressure and high temperature boilers and special materials used for big capacity steam turbines working at high pressure and high temperature may be studied. A knowledge about their working and the results is of importance to the mechanical engineers of today. Even short visits to the works engaged is more sophisticated and advanced methods of manufacturing will be of much use to the teachers of Engineering Colleges and Polytechnics. The Programme of working for about three months in industries for the Polytechnic teachers run under Quality Improvement Programme of Government of India can yield satisfactory results. Exposure to the industry and field for the teachers after every two years should be made a regular feature. If the experts from industry are called for delivering lectures to the studying engineers, it shall be of immense value. Exchange from industry to colleges and vice versa will improve the quality of technical education.

Mechanical Engineers have a little knowledge of electronics where as most of the machines now-a-days have electronic controls. As such a refreshers course in electronics engineering for the Mechanical Engineers will be of much help to them. Even the steam turbines are to be governed by electronic governors. Some of the short term courses could be :

1) Electronics Engineering applied to Machine tools.
2) Electronics used in Manufacturing processes.
3) Electronics governing of steam turbines.

This calls for the necessity of equipping oneself with latest techniques through learning. If the latest technique is not available in the country a batch of engineers may be sent to foreign countries to equip themselves with the same.

Improvement upon one's own qualification is another part of continuing education. This is more useful for the Craftsmen who have taken their certificates from Industrial Training Institutes. They wish to go up the ladder and for them regular evening courses could be started in Polytechnics, so that they could get their diplomas. These diploma classes could be held in the evening and could be of longer duration then the regular day-time diploma. Some specialization in the respective field should be there. Similarly for a technician, part-time evening courses may be run in engineering colleges. The duration of such courses could be more. Even for the students who have passed the regular diploma a provision for admitting them in regular degree courses may be made. In that case a student may be admitted in 3rd year of Five years integerated degree course. For evening degree classes, the duration of degree could be of 4 years for a diploma holder. Such arrangements are existing in some parts of country even today. Similarly, for engineering graduates a part-time post graduate degree teaching may be arranged. In such case again the duration will be 3 years in place of regular day time course of 2 years. This practice is being followed in a number of Engineering colleges. At places where no engineering colleges exist the difficulty of such continuing education facilities are being felt. For them a sequential summer school continuously for 3 years were tried but could not be successful. It is my conviction that such sequential summer schools with certain modifications may be given a fair trial so that they prepare the engineers for M E courses. The duration may be increased and the course contents may be revised. Some self studying may be encouraged.

To quote Dr Ramchandran, educating tomorrow's engineers and technicians who will be useful to the society for the next three to four decades of their professional career should be in such a way that they could 'ride the galloping horses of change'. They have the will to innovate and have the enterpreneurial spirit to modernize the old and welfare of the nation.

Continuing education centres may be located in engineering colleges. In some places where a number of industries are existing and there is no engineering college, the industries should pool together their resources to set up the continuing education centres. The faculty of such centres should be drawn up from various sources with most up-to-date knowledge and experience. Full cooperation of industries and Engineering institutions is very essential for the successful implementation of this scheme. In the end systems approach to Education with clear objectives will be very useful for the engineers of the future.

CONTINUING EDUCATION AS APPROPRIATE MODE OF EDUCATING FUTURE ENGINEER

Dr B K Sthapak *
D G Motwani **

INTRODUCTION

Education is the manifestation and development of latent capacities within an individual. Therefore, Engineering Education would mean providing a behavioural change towards developing latent engineering capabilities. A system of engineering education should envisage the development of such capacities to produce able and responsible men fully competent to practice on a professional plane, especially those who will eventually lead the profession to new heights of accomplishment through creative practice or research. There is a growing realization that education in general and engineering education in particular is a continuous process towards improvement of competence and management of human and all other resources[1,2]. For the proper and adequate utilization of these resources alongwith skills, latent gifts of individuals and increased productivity, engineering education should extend beyond the conventional system.

The conventional system of engineering education is unable to meet the yawaning gap between future demands and present state of engineering profession. Further, the opportunities for undergoing the formal education are limited and, at times, beyond means of many. It is, therefore, necessary to consider a system of continuing engineering education which will be able to meet the challenges posed by fast changing techno-socio-economic conditions and provide ample opportunities to all those who aspire for a better professional career. This paper is an attempt to study such a system of engineering education. The concept of continuing engineering education

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has been presented in terms of inputs, outputs and various governing parameters, and future requirements have been delineated. The methodology of imparting continuing education has been discussed and a plan of action has been suggested.

THE CONCEPT

Continuing education may be considered as a system of learning continuously throughout one's life, whether for intellectual satisfaction, for personal and professional progress or for the proper fulfilment of social responsibilities. The continuing education is characterized under different labels in different parts of the world[3], such as Adult Education and extra Mural Studies. In principle it ought to be shaped to meet the rapid pace of modernization acquiring effectiveness under a well structured, systematized and well chosen arrangement.

The concept of continuing engineering education in terms of inputs, outputs and various governing parameters has been shown in Fig. 1. It is observed that work experience and exucational guidance coupled with the feedback from the performance of an engineer form the basic input gradients for the education system. The desired objectives in the form of professional improvement, personality development, improved economy, filling up the technological gap between theory and practice and leadership training can be achieved by proper facilities and desire for learning associated with some kind of incentive. The importance of learning process should not be underestimated at this juncture. Learning involves something more than sheer knowledge and it should not only lead to change in behaviour but also in application to given and new situations. Incentives in the form of promotions, cash rewards, honours etc will help to motivate the personnel in this direction. The economic feasibility of the entire programme and the time required to carry out the same are the main controlling factors of the system. The time required for a given continuing education programme will depend upon the ingenuity of man in his intellectual and academic wisdom to devise ways and means of adjusting the pace of storing of knowledge within a space of time during which initial education is given.

The above concept of continuing engineering education can be appropriately utilized for educating the engineer of future provided the requiremets are well defined.

FUTURE REQUIREMENTS

Energy Scene

One of the main factors affecting the future requirements is the energy scene. Present efforts to develop and harness unconventional sources of energy like solar, wind, tidal and geothermal are the precursors of the new technology. The utilization of available energy in the best possible way would depend upon the conciousness aroused in the minds of the future engineers regarding energy conservation. The practicing engineers ought to be educated in the methodology of energy conservation.

Appropriate Technology

Our country which is poised for overall progress through rural reconstruction calls for an appropriate technology. Basically speaking, a strategy for rural transformation should include the following points :-

(1) It should assure the satisfaction of basic needs of the largest possible section of community with regardsto food, clothing, housing, etc.

(2) It should assure employment opportunities for all able bodied persons at the lowest possible drudgery in work.

(3) The employment opportunities should be organized with minimum waste of resources.

(4) All sorts of appropriate technology for the future should be correlated to planning and programming of employment.

Rapid Technological Advance

To cope with the rapid technological advances, new inter-disciplinary courses shall have to be identified, studied and utilized. Above all, the future engineer shall be required to possess the art of directing, organizing and executing the challenging jobs of engineering industry, the completion of which depends on theoretical background, logical analysis, exact measurement, value judgement and pragmatic approach. Any action plan of the continuing engineering education must, therefore, take into consideration these requirements.

METHODOLOGY

Methods of imparting the continuing education may be either formal or informal. Both methods have one thing in common that the learner possesses a breadth of live experience and self-motivation. In choosing any teaching method, it may be kept in mind that the content determines the appropriate process. Therefore, according to the course content and objectives, the following methods may be adopted for the continuing education programmes[4]:-

(1) The Lecture Method - this method of teaching though very common is subject to diverse opinions, specially because it demands little efforts on the part of the learners. But still it is a good means of giving an orderly presentation of information or, say, a systematic development of an argument.

(2) The Forum Method - information followed by questions - is suitable for specific information on particular.aspects of the discipline.

(3) The Symposium Method - offers presentation of different points of view, various approaches, useful discussion and directives on a particular topic under consideration.

(4) The Discussion Method - useful only for a relatively smaller class. The members pool ideas, experience and knowledge, and can arrive at group decisions, if decisions are needed.

(5) Field Trips, Study Tours - investigation of a real situation - useful as a part of a course.

(6) Films, Tapes, Slides, Photographs, Posters, Charts - teaching aids to be used in lectures or discussions. The choice of a particular method would depend upon the learning objectives that are anticipated as well as the facilities, time period and adoptability.

FUTURE PLAN

Fig 2 shows a plan of continuing engineering education. It is noted that field experience in a particular discipline is vital for preparation of the engineering personnel to undertake the continuing education. Part-time, special and refresher courses leading to higher qualifications, while employing the combination of lecture, forum and symposia method of teaching, are expected to arouse conciousness, a vital force for the future professional engineer. This professional conciousness is shaped into the higher level of competence when it is employed to identify the problems of engineering industries at one hand, and approach rationally towards synthesis, analysis, design, construction and operation of engineering system, on the other. Identification and approach constitute the major part of the plan of the continuing education. The suceess of the plan would depend upon the emphasis given to this part.

Role of Educational Institutions and Industry

If the above plan is to materialize, the educational institutions and the industrial organisations will have to work hand-in-hand and pave the way for the all round progress of the nation through continuing engineering education programmes.

The problem of keeping in-service personnel with up-to-date knowledge requires considerable efforts on part of both the educational institutions and industry. In order that in-service personnel may take advantage of the system either at graduate or post-graduate level, arrngements should be made for part-time, evening and correspondence courses. Also, a variety of short term courses and refresher courses will have to be organized at a larger number of institutions. It should be a joint responsibility of the Government and Industry to make available the resources for organizing such courses.

Industries and factories also must take initiative in imparting education through apprenticeship training. Several industries or a complex of factories may jointly organize common training programmes on the job integrated with theoretical instruction. This calls for the increased cooperation between the Industry and educational institutions. With close liason between the two, it would be possible to achieve the appropriate mode for educating the future engineer.

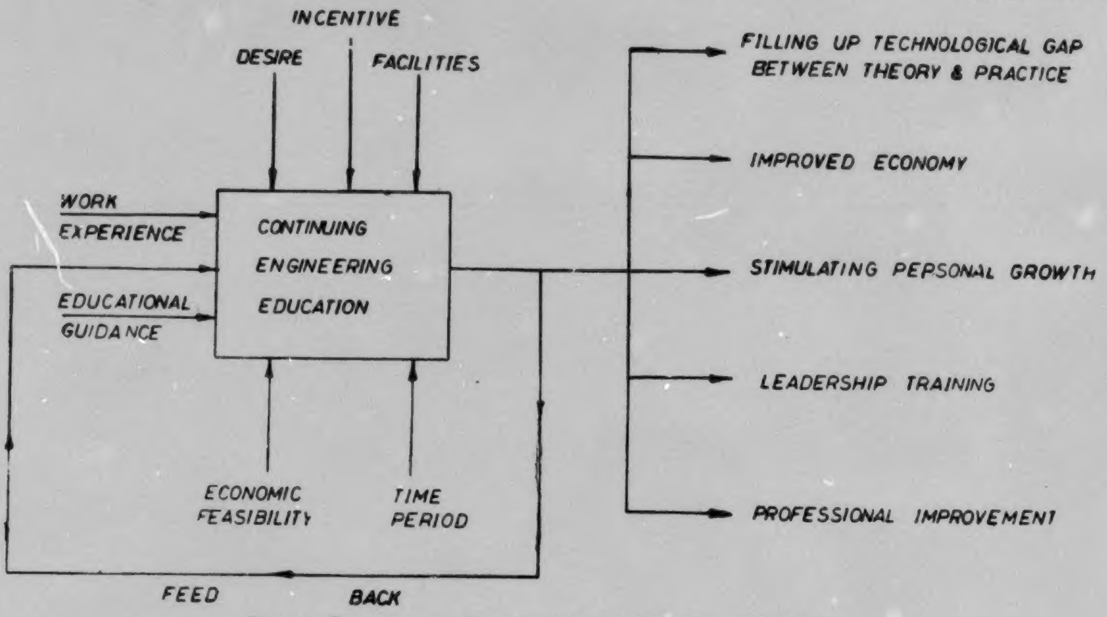
INCENTIVE
DESIRE
FACILITIES
WORK EXPERIENCE
EDUCATIONAL GUIDANCE
CONTINUING ENGINEERING EDUCATION
ECONOMIC FEASIBILITY
TIME PERIOD
FEED BACK
FILLING UP TECHNOLOGICAL GAP BETWEEN THEORY & PRACTICE
IMPROVED ECONOMY
STIMULATING PERSONAL GROWTH
LEADERSHIP TRAINING
PROFESSIONAL IMPROVEMENT

Fig. 1 Concent of Continuing Engineering Education.

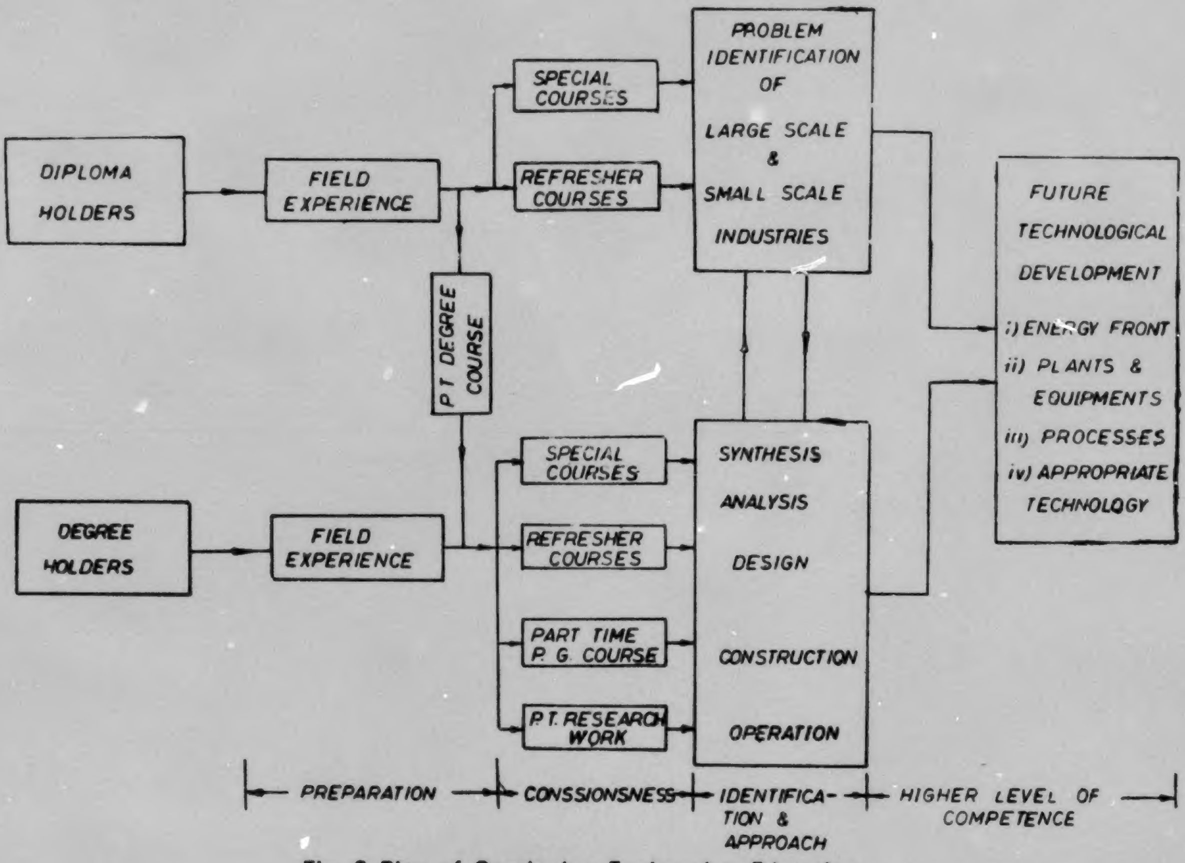
DIPLOMA HOLDERS
FIELD EXPERIENCE
SPECIAL COURSES
REFRESHER COURSES
P.T. DEGREE COURSE
PROBLEM IDENTIFICATION OF LARGE SCALE & SMALL SCALE INDUSTRIES
FUTURE TECHNOLOGICAL DEVELOPMENT
i) ENERGY FRONT
ii) PLANTS & EQUIPMENTS
iii) PROCESSES
iv) APPROPRIATE TECHNOLOGY
DEGREE HOLDERS
FIELD EXPERIENCE
SPECIAL COURSES
REFRESHER COURSES
PART TIME P. G. COURSE
P.T. RESEARCH WORK
SYNTHESIS
ANALYSIS
DESIGN
CONSTRUCTION
OPERATION
PREPARATION
CONSSIONSNESS
IDENTIFICATION & APPROACH
HIGHER LEVEL OF COMPETENCE

Fig. 2 Plan of Continuing Engineering Education.

CONCLUSIONS

On the basis of foregoing, the following conclusions are drawn :-

1. The limitations of conventional system of engineering education calls for a continuing engineering education system to meet the future challanges of the engineering profession, specially in the context of rapid obsolescence of technological processes, skills and techniques.

2. Continuing engineering education is the most appropriate mode of identifying, studying and achieving the higher level of competence. It is expected to serve future requirements of the energy front by conservation of existing energy and harnessing new energy resources; and by developing appropriate technology to raise employment opportunities for all able bodied persons at lowest possible drudgery in work thereby ensuring overall progress. The engineers of the future may, therefore, be educated through this system.

3. The methodology of the continuing education may consist of a combination of lectures, forums and symposia type of teaching in the form of part-time, refresher and special courses.

4. The close liason between engineering educational institutions and industry would help in planning and executing the system of continuing engineering education.

REFERENCES

1. G . G R Damodaran. 'Technical education in India - Looking back and forward', The Education Quarterly, Vol XXIV, No. 4, January 1973, p 5.

2. K Basavaiah. 'The relevance of the concept of life-long education in modern Life', The Progress of Education, Vol L Nos. 10-11, May-June 1976, p 200.

3. M S Mehta. 'Concept of University continuing education'. Report of the Regional Conference on Continuing Education, held at Hydrabad, U G C, New Delhi, 1976, p 7.

4. Virginia Shrivastava. 'Methods and Learning Process in a continuing education programme in a University'. Report of the Regional Conference on Continuing Education held at Hydrabad, U G C, New Delhi, 1976, p 40.

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REORGANIZATION OF ENGINEERING EDUCATION TO CATER TO NEEDS OF NEWLY EMERGED FIELDS OF ENGINEERING IN GOVERNMENT DEPARTMENTS AND INDUSTRY

J S R MOHAN RAO*

COURSE CONTENT OF PRESENT DAY ENGINEERING EDUCATION

The subjects taught at the undergraduate stage of the present day engineering education may be classified broadly under three heads, viz (i) English language and general sciences including Mathematics, Physics and Chemistry, (ii) basic and general engineering subjects and (iii) specialized and applied engineering subjects. The importance attached to each one of these three groups in the undergraduate course may be again judged by the cumulative time allotted to the respective groups in the entire course extending over a total period of 10 semesters or 5 years. The cumulative time allotted to English language and general sciences sums up to 2 to 3 semesters or 1 to 1½ years, while basic and general engineering subjects take about 6 semesters or 3 years, leaving hardly 1 to 2 semesters only, that is, ½ to 1 year; for the specialized and applied engineering subjects which are of real significance and application to the engineer in the industry. The case of Civil Engineering discipline is typical in this respect, the position being slightly better in the case of the other two general engineering disciplines, viz, Mechanical Engineering and Electrical Engineering. While the basic and general engineering subjects taught in the Civil Engineering discipline range from Hydraulics, Soil Mechanics, Applied Mechanics, Strength of Materials, Theory of Structures, Geometrical Drawing, Building Drawing and Surveying etc, which take a cumulative period of about 6 semesters, the specialized and applied engineering subjects which take a cumulative period of less than 2 semesters cover a wide range of subjects from Irrigation and Drainage, Hydrology and water Resources, River Valley Projects, Docks and Harbours, Water Supply and Sewage to Roads, Railways, Airfields and Buildings etc. There is hardly any specialized course in the Civil Engineering field at the undergraduate stage at present, except, perhaps, Highway Engineering course, which is again not well patronized by the students, unlike in the field of Mechanical Engineering where there are a few purposeful specialized courses at the undergraduate stage, such as Automobile Engineering, Aeronautical Engineering, Marine Engineering and Metallurgical Engineering etc, though the glamour and demand is still more for the general Mechanical Engineering course.

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THE DRAWBACKS

Whereas the total period of 2 to 3 semesters allotted for teaching English language and general sciences is on the high side, the period of only 1 to 2 semesters allotted for teaching the specialized and applied engineering subjects is on too low a side. While teaching of English language may be dropped altogether in the undergraduate engineering course in as much as the student is expected to have acquired fairly good knowledge of the Language at the Intermediate education stage with all the prose and poetry lessons, nondetailed lessons and grammar and essay and precise writing exercises included in that syllabus, the teaching of general sciences may be reduced to a considerable extent by omitting the elementary portions already taught at the school stage and reducing the advanced portions to be taught to the minimum and to the individual requirements of the respective disciplines of engineering only and not as common subjects catering to the total requirements of many disciplines put together. For example, Physics and Chemistry need not be taught much in the Civil Engineering course, while Mathematics and Physics may be taught more in the Electrical Engineering and other allied courses of engineering and more of Chemistry in the Metallurgical and Chemical Engineering courses. Teaching of Higher Mathematics also may be minimized to the requirements of undergraduate course only in the particular discipline, leaving further knowledge required for the postgraduate course to be acquired at the post graduate stage itself. All the time thus saved by minimizing the teaching of languages and general sciences may be utilized for teaching more of specialised and applied engineering subjects or for reducing the overall course period from 10 semesters to 8 or 9 semesters.

BASIC AND GENERAL ENGINEERING SUBJECTS

The most important part of the engineering education at the undergraduate stage is the teaching of basic and general engineering subjects. This is the basic knowledge one has to acquire to acquire proficiency in any branch of engineering. The present system of engineering education takes the students roughly about 6 semesters or 3 years to acquire this knowledge and this period may be considered essential for any effective engineering education. A few modifications may be, however, brought in here and there to make this period more and more oriented to any particular branch of engineering, cutting down subjects pertaining to the other branches. For example, in the Civil Engineering course, subjects like Mechanical Engineering, Electrical Technology, Hydraulic Machines and Workshop Practice etc. may be dropped. This three year period of education in basic and general engineering subjects in any branch of engineering may be aptly called the undergraduate course in general engineering sciences in that particular branch of engineering and a degree in general engineering sciences in a particular branch of engineering, viz. B Sc (Engg) (Civil), B Sc (Engg) (Mech), or B Sc (Engg) (Elect), may be awarded at the end of this three year course in recognition of the fact that the student has attained proficiency in the basic and general engineering sciences in the respective branch of engineering, similar to a degree in general sciences. This sort of compartmentalization of the engineering course at the general engineering education stage will enable the student to acquire a degree and seek employment in the administrative and managerial lines of nontechnical or semitechnical nature, just as any other science graduate, if he so desires.

FIRST STAGE SPECIALIZATION AT THE UNDERGRADUATE STAGE

The pattern of the present day engineering education, in teaching each and every specialized and applied engineering subject allied to a particular branch of engineering, is not at all conducive to the professional requirements of the over so many newly emerged and emerging fields of engineering of the expanding Government departments and industries. With a few exceptions of such specialized courses like Automobile Engineering, Aeronautical Engineering, Marine Engineering, Metallurgical Engineering, Textile Engineering, and Highway Engineering etc, there is no worthwhile change in the course content and outlook of the engineering education at the undergraduate stage which was evolved in the preplan and preindependance days. For example, in Civil Engineering, so many specialized applied engineering subjects, ranging from Irrigation, Docks and Harbours, Bridges, Hydrology and

Water Resources, River Valley Projects, Water Supply and Sewage to Roads, Railways, Airfields and Buildings etc., are taught in a brief period of 2 semesters or 1 year at the most, that the student, at the end of the course, proves to be neither a jack of all trades nor a master of one.

But, with the advent of the five year plans and developmental activities undertaken mostly in the engineering fields, on gigantic scales to rebuild the country to make the nation self-sufficient, self-supporting and prosperous, the need for greater and detailed knowledge and expertise in many newly emerged fields of engineering activities is being felt more which is not reflected in the course content or outlook of the present-day engineering education at the undergraduate stage. Nation building activities like construction of gigantic multipurpose river valley projects, major irrigation projects, huge hydro-electric and thermal power projects, massive irrigation systems, large-scale diversions of major rivers in establishing national water links, long span bridges on big rivers and multistoreyed framed buildings etc in the Civil Engineering field, apart from various other constructions in the other engineering fields, are multiplying by leaps and bounds and there will be no stop for these works in the foreseeable future. But the fact remains that there is only one common course available in Civil Engineering at the undergraduate stage, with the lone exception of Highway Engineering, which in turn is not quite popular, to train up engineers to be engaged on all these major construction activities and many more. Again, all the specialized applied engineering subjects, crammed in the syllabus in the brief period, are almost in the old obsolete form without the inclusion of many of the advancements made in different fields. The syllabii of almost all these specialized applied engineering subjects need to be revised, redrafted, enlarged and updated by the faculty, incorporating the latest advancements and applications made on the field and in the industry in the recent past, in collaboration with the engineers actively engaged in the respective spheres in research, design, construction, operation and maintenance activities in the Government departments and the industry.

The basic principles and theoretical aspects of designs covered in the syllabus cannot keep the engineer in good stead in tackling the manifold field problems encountered in the investigation, planning, design, construction, operation and maintenance of varieties of structures involved in all the different individual fields embraced by the general Civil Engineering field. The training imparted in the preparation of designs and drawings with greater accent on preparation of drawings and less on designing and nothing on investigation, planning, operation and maintenance, is too sketchy and scanty. Design engineering is, actually, an applied art of engineering. While engineering itself is, in general, an applied science, design engineering dealing with the application of engineering principles and science in any field of engineering is applied engineering, requiring quite a lot of ingenuity and practical outlook and approach to the various engineering problems. This is more so in the field of Civil Engineering, which is not even as exact a science as the other fields of engineering. Next, foundation investigation is an important aspect in the design and construction of any engineering structure. Such foundation investigation will have to continue, in some cases, even after the design is finalized and the structure is taken up for construction, if the original investigation is not complete and perfect due to various reasons. On the construction side, there are the field problems of dewatering for foundations, form work for concrete, centering for superstructure, drawing up construction plant and layout and construction schedules and programme and working out the requirements of construction materials, machinery and labour and organizing the work etc. On the maintenance side also, ever so many problems are faced, for example, repairing slips and breaches in the earthen banks, undermining of foundations of structures, outflanking of bank connections, and damages to side walls etc in the field of Irrigation Engineering.

When once the syllabii of the various specialized applied engineering subjects are enlarged and updated, it will be neither required nor possible, any longer, to teach all these allied subjects in the Civil Engineering field in particular, to any degree of practical utilization value. Each subject assumes large proportions, which can be taught exclusively as an independent course at the undergraduate stage. For example, Irrigation Engineering covers so many subjects as Hydrology and Water Resources, River Valley Projects, Irrigation Canals and Canal Structures and Irrigation Systems as such including actual irrigation, drainage and allied agricultural aspects etc. A student who studies Irrigation Engineering at the undergraduate stage need not bother about employment potential or prospects in planning his career after leaving the engineering college. Hence there will be no need for him to learn any of the other applied engineering subjects in the Civil Engineering group, such as Roads or Railways or Buildings or Water Supply and Sewage etc. Similarly Water Resources Engineering, Public Health Engineering, Railway Engineering, Highway Engineering, Building Engineering and so on. On similar lines, there must be more specialized c courses at the undergraduate stage in the Mechanical Engineering and Electrical Engineering fields as well, to cater to the needs of the newly emerged fields of engineering in the Government departments and in the industry. In these days of ever increasing and multiplying activities with attractive job opportunities and absorbing talent utilization in each individual field of engineering activity, there is every need to resort to some sort of first stage specialization at the undergraduate stage itself. The entire final year of the present undergraduate course may be devoted for this first stage specialization and post-graduate diplona, viz, P G Dip, may be awarded at the end, in continuation of the degree in general engineering sciences offered at the end of the first three years of the course, in recognition of the general specialization attained in a particular discipline in a particular branch of engineering. This sort of general specialization in the last year of the course will also enable the student to study for one more year in the college and acquire proficiency in one more discipline in the respective branch of engineering, if he so desires, either to better his prospects or change his line of profession without any special provision made in the college curriculum.

COMMON RECRUITMENT AND SERVICE POLICY

With the introduction of the first stage specialization at the undergraduate stage of education, the field of activity and operation, both for study and profession, gets limited and better defined. To remove the feeling of reduced job opportunities consequent to the abolition of the present general engineering courses of Civil, Mechanical and Electrical Engineering and to improve upon the job opportunities and promotion prospects in each individual field of engineering in the country as a whole, the recruitment and service policy of the Government departments in these fields need reorientation and reorganization. Just as in the case of Railways, Major Industries, Steel Plants and Fertilizer Projects etc, all Major Irrigation and Power (both Hydro and Thermal) Projects and Highways etc must be brought under the aegis of the Union Government with centralized services for each branch of engineering. The initial recruitment of all the graduate engineers to the Government departments and industries must be to a post equivalent in rank, status and pay to those of a Class II gazetted post, apart from the usual direct recruitment to Class I junior posts based on merit and selection.

CONCLUSION

To sum up, it is suggested that -

(i) the teaching of English language may be dropped from the undergraduate engineering course,

(ii) the teaching of general sciences, including Mathematics, Physics and Chemistry, may be minimized to suit the individual requirements of different branches of engineering for the undergraduate course only,

(iii) the extent of teaching of basic and general engineering subjects, as prevailing in the undergraduate course, is essential and may continue almost in toto, but with a few modifications to make it more oriented to the individual branches of engineering, and a degree in general engineering sciences in the particular branch of engineering, viz, B Sc (Engg) (Civil) or (Mech) or (Elect), may be awarded at the end of this three year course, similar to a B Sc degree in general sciences,

(iv) the present teaching of specialized and applied engineering subjects at the undergraduate stage is too sketchy and scanty with too many subjects crammed in the syllabus for a brief period of hardly one year,

(v) the syllabii of almost all the specialized and applied engineering subjects need to be revised, redrafted, enlarged and updated by the faculty, incorporating the latest advancements and applications made on the field and in the industry in the recent past, in collaboration with the Government departments and the industry,

(vi) more specialized courses must be introduced at the undergraduate education stage, in place of the existing general engineering courses of Civil, Mechanical and Electrical, especially courses like Irrigation Engineering,*/ Railway Engineering, Highway Engineering and Building Engineering etc in the Civil Engineering field, and a post-graduate diploma, viz P G Dip, may be awarded at the end of this first stage specialization at the undergraduate stage, complementary to the degree in general engineering sciences offered earlier,

*/ Water Resources Engineering, Public Health Engineering,

(vii) to improve upon the job opportunities and promotion prospects in the country as a whole, all major irrigation and power projects and highways etc must be brought under the aegis of the Union Government with centralized services for each branch of engineering, just as in the case of Railways, Major Industries, Steel Plants and Fertilizer Projects etc, and the initial recruitment of all the graduate engineers to the Government departments and industry must be to a post equivalent in rank, status and pay to those of a Class II gazetted post.

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EDUCATIONAL STRATEGY FOR MINERAL INDUSTRY - A FORWARD LOOK

A K Ghose*

R D Singh*

INTRODUCTION

Minerals can be regarded as man's principal physical material in the development of industrial civilization. With a rich and hoary tradition, mining in India dates back to pre-Harappan days, as recent carbon dating of artifacts from old mine workings testify. Kautilya's *Arthasashtra* written about 300 B.C., records that 'mines are the sources of treasure', the presence of old diggings, of mine workings, slag heaps and other remains found in major mineral districts all make evident that there was a flourishing mining industry in the past.

Though in the post-independence era, there has been an impressive development in mineral production in the country (Table I), the exploitation of the natural resource endowment is still largely an area of intermediate technology. The industry has been hedged in for too long a time by slow rate of technology transfer. All the same, then there are clear signs of sophisticated technology finding application in the mineral industry and it would be apposite to examine the relevance of the present-day educational system for mineral industry situation.

There have been many points of view - in fact a plethora of them - on the strategy for preparing mining engineers of tomorrow. Round-tables on training needs for mining engineers for the year 2000 were held during the 8th and 9th World Mining Congress(1,2) at Lima (1974) and Dusseldorf (1976) which surfaced the conflicting viewpoints on the need for 'specialist' and 'generalist' engineers for the mining industry. The Indian situation has been examined by Singh(3), while Ghose(4) has made an anticipatory assessment of mining engineering education using the relevance-tree concept.

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MINING EDUCATION IN INDIA -- ITS PAST AND PRESENT

Mining education in India, which completed the half-century mark only a couple of years ago, has by and large followed the pattern of education in Britain. Steeped in classical tradition, the educational system was an inheritance of the colonial rule which sought to create and provide for a breed of 'managers' to subserve the interests of the 'ruler' or the private entrepreneur. The educational system was not geared to either technology generation capability or technology-implementation capability and was not perceived as an instrument to catalyze technological growth. There had been little search for relevance and a modicum of effort was made to match the educational system to the profile of the mineral industry needs. The institutions in the mineral industry became therefore veritable 'sausage machines' grinding out endless strings of graduates (often causing a glut,). The curricular changes have been somewhat conservative and the inherent time lag of the educational process resulted in the curricula being continuously out of tune with the current needs of the industry. Whilst by hindsight it is easy to decry the past efforts (and the blame could as well be apportioned to the status of technology), the aggregate effect was reflected in the 'average' quality of the graduates the majority of whom were neither trend-setters nor innovative. The minimal level of technology transfer and diffusion in the mineral industry is perhaps reflective of the level of education. Constrained by chronic shortages of funds, limited infrastructure and practically no post-graduate programmes of study and research, the mineral engineering institutions operated in a static way, unaffected by the mainstreams of developments in the technological arena, or for that matter, of national needs and priorities. While quantitatively, there have been encouraging developments *vis-a-vis* gains in the outturn of graduates (Fig 1), the employment situation witnessed abrupt changes and the mismatch in the output profile from mineral engineering schools and the demand profile of the mineral industry, caused serious imbalances and unemployment.

The current challenges facing mineral industry education are unique, though not necessarily intractable. The rapid growth in the level of mineral production, the emergence of giant public sector organizations in the mineral industry and the need for higher levels of skill in planning and design in the past decade has heightened the level of interest in mineral engineering schools and a fresh look at the educational goals and strategies. The educational institutions have been refurbished with significant funding for development of infrastructure and enlargement of faculty strength and also for post-graduate studies and research. Lately, new experiments are under way which promise significant changes in programmes, content and form of mineral engineering education including the offering of electives and requirement of mini-thesis at the undergraduate level itself.

UNIVERSITY/INDUSTRY INTERFACE

It is widely recognized that mining engineering education must be nurtured by establishing viable linkages with the industry for the common purpose of advancing technical knowledge and of bringing enlarged outlooks and perspectives to both the industry and institutions. The barriers have now been lowered and the wide chasm that separated the mineral industry with the educational community has been largely bridged by active industry support for a wide range of research projects. Within an appropriate and mutually agreeable framework of co-operation, viable linkages have been established, which needs to be further reinforced. As an educational strategy, for instance, it is only during the last five years that new chairs and visiting faculty positions have been created with assistance, from the industry. Part-time teaching, consultancy, and collaborative research programmes with largescale industry support have stimulated the educational process and a new wind of change has been sweeping the educational scene. Besides assistance for organization of practical training of students, several cooperative programmes (like condensed degree programmes) have now been possible, while the industry's needs for specific categories of technical manpower are being increasingly met through non-formal education. The increasing interaction through consultancy assignments, offered by the industry, has enabled the faculty members to gain new insight into practical problems.

That the co-operation between the mining institutions and the industry is a mutually beneficial continuing interaction across an interface having many channels is beyond question, and needs to be strengthened.

SEARCH FOR QUALITY TEACHING

To make the 'quality' of mineral engineering education relevant to the changing needs of the industry will call for a number of strategic and tactical approaches, including amongst others, curricular revisions, new course offerings and lowering the barriers between the industry and the educational institutions. In searching for the educational goals, the question facing the educator is how far and where to set the sights. Should mineral education be aimed towards the immediate tomorrow or for the next 30 years ? Should the programmes prepare the student for jobs immediately on graduation, or should they be so prepared with broad general engineering training capable of self-learning and tackling new challenges. These are necessarily vexed questions.

While the content of mining engineering education will largely be governed by technological changes, two important trends are discernible. First, the breadth will have to be reduced and make way for intensiveness and specialization. Secondly, the curriculum must include larger dosage of 'management', 'design' and 'synthesis'. It is clear that in the near future there will be increasing specialization at the undergraduate level itself with branching off into different streams of engineers prepared for surface mining, underground metalliferrous mining, coal mining, etc. New engineering disciplines, such as those of mining machinery, mineral engineering and mine surveying, may also emerge. Increasing involvement in research by the mineral engineering schools will aid the teaching process both at the undergraduate and graduate level.

There is no doubt whatsoever that engineering education for the mineral industry is going to change its form also in the future due to the impact of new technologies and the increasing importance of engineering education continuing over the complete professional life of an engineer. The traditional lecture, recitation and examination approach will be largely supplamented by new concepts of 'Resource Based Learning', new instructional systems, and flexible programmes. It is also possible that there will be a trend towards 'piecemeal' education, where the technological curricula may be structured to enhance the employability of an individual.

CONCLUSION

Educational systems in the mineral industry is on the throes of changes in programmes, content and form, under the inexorable force of technological developments. Innovative reforms in the educational profile are being searched for and introduced to prepare engineers for the mining industry for the year 2000 and beyond, equipped with the knowledge and skills to cope not only with the current situation, but also to anticipate the shape of things to come and to meet the challenge of the future.

REFERENCES

1 Proceedings of the 8th World Mining Congress, Lima, Peru, 1974.

2 Proceedings of the 9th World Mining Congress, Dusseldorf, 1976.

3 R D Singh, University Education for the Mining Industry - Shape of Things to Come, Journal of the Institution of Engineers, Vol XLVI, No 5, Pt GE2, January 1966.

4 A K Ghose, Technology Assessment and Forecasting for Mining Engineering Education to Year 2000, Journal of Mines, Metals & Fuels, February, 1976.

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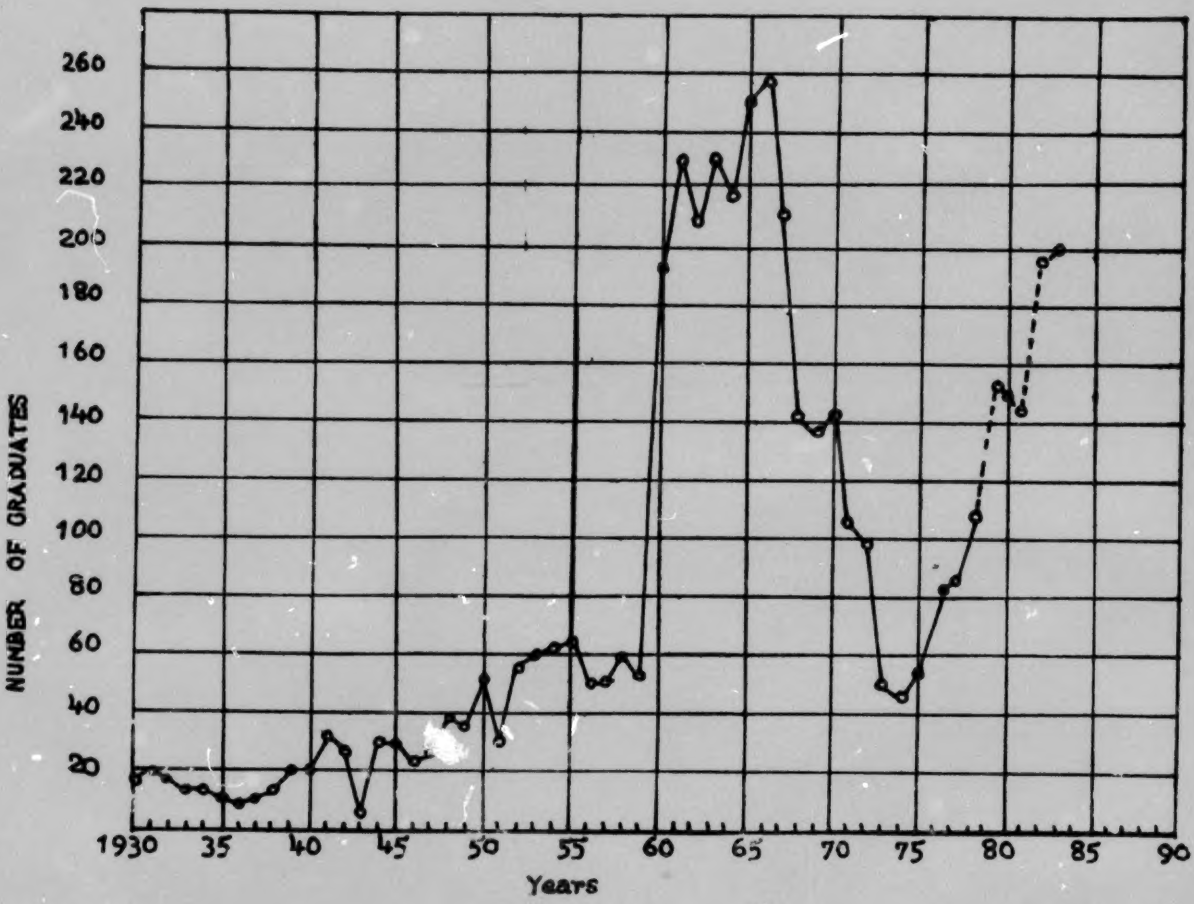

Fig. 1 NUMBER OF GRADUATES

TABLE - 1

Minerals in Indian National Economy

	Years					
	1950	1955	1960	1965	1970	1975
Gross value of Mineral production total, in Rs. mill	716	934	1,650	2,905	4,888	10,603
(i) Mineral Fuel	467	560	1,115	1,960	3,487	7,904
(ii) Metallic minerals	138	244	326	381	620	1,337
(iii) Non-metallic minerals	111	130	209	563	781	1,363
Value of mineral production as percentage of GNP	0.9	0.9	0.9	1.0	1.0	1.4

NOTES :

1. The gross value is at current prices.
2. From 1960 onwards the figures are inclusive of petroleum and natural gas, value of mineral output from Goa, but exclusive of atomic minerals.

EDUCATING ENGINEERS OF FUTURE IN EMERGING PROFESSION OF QUALITY ENGINEERING

R N Bosu *

INTRODUCTION

During early stages of industrialization the producer and consumer were an integrated body who knew exactly what they wanted and endeavoured to achieve the objective. They could also assess, by experience, if the product was good enough to satisfy the requirements of the particular application. With the present-day technological explosion the situation has completely changed. Not only that the producer and consumer have been widely separated with interposition of marketing agency, the producing body itself has become an immensely complex system[1] comprising the essential ingredients like design, process engineeting, production planning, quality assurance, market survey, product improvement etc, with a view to achieving an optimum exploitation of the scientific and technological advancements. The consumers, on the other hand, have become increasingly aware of the technological benefits and consequently there has been a steadily growing complexity in the aspirations among the consumers.

CONSUMERS' ASPIRATIONS

Consequent on the phenomenal developments in the industries, mass production, mass distribution, education and general upliftment in the economic strata, the modern consumers of any technological product or Service, by and large, exhibit a rapidly emerging pattern of aspirations, as appended below :-

(a) The products should be the outcome of the latest technology and obtainable at a reasonably low cost.

(b) The products must be a quality one with assured 'fitness for use'.

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* Controllerate of Inspection (Special Vehicles) Dehu Road, Ministry of Defence (DGI).

(c) The products should render satisfactory service continuously for a reasonably long period of usage. Even after any eventual discontinuity in service, the products should be amenable to revival of original service-efficiency with the least possible delay, inconvenience and capital outlay.

(d) There should be an assurance of safety in normal exploitation of the products and services.

SOCIAL OBLIGATION

The Consumers' aspirations, indicated above, are undoubtedly obvious and they sound quite reasonable. Apart from this, there is another important aspect as to the inescapable obligation of the technology to the society. A society which supports the technology in all its phases can reasonably demand that the technology should evolve a system which could guarantee and fulfil the natural aspirations of the consumers of the technology in making available an up-to-date, economical, efficient, reliable and maintainable product with in-built safety - a service so vital to the society.

FULFILMENT OF ASPIRATIONS AND OBLIGATIONS

The fulfilment of the above mentioned aspirations and obligation depend on the efficacy of the various aspects of the quality of the products or services, for example, quality of design, quality of conformity, quality of performance, etc.

In the earlier days, quality awareness was hardly pronounced in the majority of the consumers, for a number of reasons. The demand for quality assurance emanating from a small segment of consumers of rather primitive technology, involving much simpler products and services, could be reasonably met by un-aided senses, normally at the final stage.

A modern technological product, almost invariably is an outcome of series of complex interdisciplinary interactions which defies the application of the outmoded idea of its evaluation by unaided senses at the final stage. In fact, the term 'inspection', in this context, has long been discarded in favour of terms like 'quality assurance' and 'total quality control'.

The complex interdisciplinary interactions, stated above, have also rendered the monitoring and total comprehension of the product quality by the various disciplines and agencies, an increasingly difficult task, though the international spate of standardization was of assistance, in this respect but only to a limited extent. Thus, the state of affairs, was far from satisfactory which led to the growing realization that since the existing conventional disciplines do not meet the full requirements there has to be a specialized service, adequately equiped with a codified body of appropriate knowledge involving a series of scientific disciplines, which could do justice to the exacting task of quality assurance of the modern complex technological products and services.

It was also realized that the all important economic viability of any industrial venture, contrary to the popular belief, depends to a very large extent, on the efficient management of quality assurance activities, rather than compromising them. In fact, in a properly controlled production system, quality becomes synonymous to profitability.

EMERGENCE OF 'QUALITY ENGINEERING'

In the background of the factors enumerated above, it was an economicand social imperative to give birth to a new group of specialists under the banner of an emerging discipline, called 'Quality Engineering'.

However, as brought out earlier, the existing conventional disciplines do not meet the full requirements of quality engineering and therefore, attempts were made to train up the engineers of the conventional disciplines to meet the immediate requirements. Thus, the education available to the quality practitioner to enable him/her to perform the task inherent in the speciality, was so far, majorly task oriented and was often inadequate.

The recent years have borne the emphasis on a broad-based and career-oriented education, bringing out the inescapable array of interdependent features, such as statistical methodology, quality planning, vendor relations and rating, reliability engineering, mathematical statistics, metrology, environmental science, physical science, management science, process control, quality cost analysis, data system, quality monitoring etc. In fact, quality engineering seems to have emerged as an all pervading profession which deals with the entire route of journey of a technological product, viz, design specification, process engineering, purchase, instrumentation, operation, inspection, marketing, consumer-experience analysis, R & D and feedback.

PROFESSIONALISM IN QUALITY ENGINEERING

Juran[2] has examined the case of professionalism in quality engineering in considerable details. It has been creditably established that the new discipline of quality engineering satisfy the salient criteria of a profession. It is interesting to recall some of the criteria like (i) performance of a service vital to the society (ii) requirement of a specialized and codified body of knowledge for performance of the service (iii) requirement of education and training for a career in the speciality (iv) qualifying examination (v) requirement of a licence to practise (vi) code of ethics etc. Thus Quality Engineers of tomorrow are expected to conform to the requirements associated with any other profession, viz, medicine, law, etc before they are permitted to practice, that is, before the responsibility of ensuring the vital aspects like safety and continuity of complex and critical products and services to the society could be reposed on them.

ACCEPTANCE AS PROFESSION

In recent years, there has been unmistakable trends to show that the profession of quality engineering is steadily gaining recognition. Some of the Universities and Institutions have already incorporated the new discipline in their regular curricula. For instance Wayne State University (Detroit) offers degree in Bachelor of Engineering Technology in quality and California State University (Long Beach) offers a degree of Bachelor of Industrial Technology in quality. There are several others in the field offering various specialization, viz, degree in reliability engineering, Master in Quality Management, etc.

In fact the state of California[2] recognizes the title of 'Quality Engineers' as a distinct entity and individuals are permitted to use this title only when they are duly qualified to do so.

The American Society for Quality Control (ASQC), has started a certification programme for the quality control specialists and the dimensions achieved[2] are given in Table 1.

TABLE 1 CERTIFICATION OF QUALITY SPECIALISTS

Category certified	Year of Commencement of programme	No certified as in Dec 1975
Quality Engineer	1966	5279
Reliability Engineer	1972	1034
Quality Technician	1972	289

Likewise, the status of the quality assurance department in the industrial hierarchy is also an indirect index of acceptance or recognition of the profession. The limited censuses taken by Juran[2], on the basis of the statures of the top quality officers in the industrial companies in USA and Europe, reveal the position as given in Table 2.

TABLE 2 STATURES OF TOP QUALITY OFFICERS

Top Quality Officer reporting to top executive	Proportions of top quality officers	
	In USA	In Europe
Directly	55	28
Through one intermediate level	45	56
Through two intermediate levels	-	16

From the above, one can visualize that the emerging profession of quality engineering is fast gaining ground, as far as the recognition of the profession is concerned.

SUGGESTED COURSE OF ACTION

Keeping in view the social and economical imperatives involved in the profession of quality engineering and also the trend of developments, in this regard, in other countries it is only appropriate that we also rise to the occasion and take suitable actions to educate the engineers of the future in this important discipline.

In the opinion of the author, the task should be executed in two distinct phases. In the first phase, a compulsory course, outlining the salient features of quality engineering (or say, quality and reliability engineering) should be incorporated in all the undergraduate courses of engineering; postgraduate specialization should be offered to supplement this course. In this connection, it is heartening to note that a Workshop was held at Roorkee University in March 1978 to evolve the syllabus for a compulsory course in Quality and Reliability Engineering for the undergraduate engineering courses. A separate paper is being presented at this Seminar, highlighting the deliberations on the subject. The compulsory course, mentioned above, will go a long way to meet the immediate requirements of the profession in general and a long-felt necessity in the Defence Inspection Organization, in particular.

In the second phase, we should be able to offer Bachelor's degree in Quality Engineering and its post-graduate specializations including doctoral programmes.

CONCLUSION

In conclusion, it may be stated that the emerging profession of Quality Engineering has come to stay in its own right. We must take a pragmatic view of the situation and make suitable arrangements to educate the engineers of the future in this all-pervading discipline, so that the foreseeable technological challenges can be met with planned fortitude.

REFERENCES

1. J M Juran, L A Sedar and F M Gryna. 'Quality Control Handbook', Second Edition 1962, Mc GrawHill Book Company, New York.

2. J M Juran. 'Emerging Professionalism in Quality Assurance' Journal of the Institute of Quality Assurance 2 (3), 71-77.

EDUCATING ENGINEERS OF FUTURE IN NEWLY EMERGING BRANCHES OF ENGINEERING —— A CASE STUDY : AGRICULTURAL ENGINEERING

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K R Swaminathan**

GLOBAL OUTLOOK OF AGRICULTURAL ENGINEERING PROFESSION

During the past decades agricultural engineering education has been characterized by continuous change. The emphasis in the recent past has been on science in the education of engineers. This has resulted in addition of more mathematics, physics and chemistry in undergraduate engineering curricula. The underlying philosophy of associating engineering education with the science and mathematics is to build greater flexibility and diversity into the engineering education. It is known that the three principal labour-consuming area in any diversified farm enterprise, whether in USSR, USA or any other country are (a) major field crops like cereals, (b) farmstead operations and (c) special crops like plantations and horticulture. In USSR there are three types of farm units, namely collective farms, state farms and private plots permitted under collective farms. Labour force includes state farm employees and certain other categories of workers. In USSR, even though there is a steady increase in mechanization, hand labour is used for hoeing and weeding with very little use of hybricides for weed control. In USSR there are seven institutions where agricultural engineers are trained. The departmental structure varies from one institute to another, but is based on subjects very similar to those in USA. The students in USSR study general and basic courses the first 2 years, specialize in the major field the last 3 years. They spend approximately the same time as students in USA in mathematics, mechanics, strength of materials, kinematics, thermo-dynamics and more in machine design, tractor design, repair and practical applications and less or very little time in humanities, languages and natural science at the institute level.

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Though agricultural engineering has only recently been recognized as a distinct branch of the profession in Newzealand, agricultural engineering subjects have been taught for many years as part of the courses leading to the bachelor of agricultural science degrees and the diplomas in agriculture at the colleges of agriculture at Lincoln and Massey. In 1966, a joint professional programme was initiated by Lincoln College and the School of Engineering of the University of Conterbury. The very high level of productivity per unit of labour attained in Newzealand farming is due to a favourable climate. It is estimated that about 28% of farming capital is in machinery and farm structures. The curricula include the fundamental principles of engineering, physics, biology and agriculture and identification of practical problems and their solutions. The current studies contain soil and water studies including hydraulics, mechanics, water resources development, methods and management, rainfall-run-off relationship, erosion and soil conservation, farm mechanization for (a) operations like seed/fertilizer application, threshing, (b) crops like fodder beet, rasp-berries and (c) on-farm power. Environmental control, equipment for livestock husbandry system and operation research, rural waste control and utilization studies find place in graduate and postgraduate programmes.

In USA humanities, basic sciences, agricultural sciences, basic engineering subjects and agricultural engineering subjects are taught in varied proportions as given in Table 1.

Since 1946 in India with an intake of 40 students in the Allahabad Agricultural Engineering Institute, the strength of undergraduate admission has increased to 330 as can be seen from the Annexure. The proportional constituents of the curriculam is given in Table 2 for seven institutions.

BASIC VARIATIONS IN UTILIZATION OF AGRICULTURAL ENGINEERING SKILL

The agricultural engineering profession is the application of engineering skill for agriculture. But in view of the fact that the agriculture itself is a varying venture in different countries and regions, the applicability of the engineering skill is very much location/objective specific. Hence the development of agricultural engineering skill is to be devetailed to the specific needs as follows:

a) National policy based professional skill development

b) Crop based cultivation oriented skill development

c) Skill development based on agriculture-industry inter-relationship

d) Skill development based on socio-economic needs.

National Policy

The two important policies which dominate the national picture are the need for rural development and the generation of employment potential. The agricultural engineering profession imbibe these two facets within itself. By giving proper shaping to this professional growth, the existing image of the rural industries can be changed. The following three areas are identified which can be included in the agricultural engineering education. They are:

a) Village industries that can produce agricultural implements and machinery of farmers' need and capacity

b) Custom hiring and servicing units to meet the operational demands of farming business

c) Conjuncting the allied industrial endeavour of the rural base through agricultural base; Example

sugarcane, vegetable oil, plantation commodities.

These aspects embrace the applied skill of other engineering branches like production technology, chemical engineering, management etc.

Crop Based Cultivation

Moisture conservation is the vital need of the country as the majority of the land is under dry farming. There is an urgent need to develop technology that will benefit the farmers of the region. Similarly there are a few crops which are dollar earning cash crops. They include spices, cashew, tea, coffee, essential oils, etc. The need to develop skill to handle such crops not only for labour saving but also to promote the quality of end-products is very much required. The three prime components which determine the requirements of a machine in farming are low energy level, less time consuming factor and high net return. The skill to meet the desired component is again situation-bound .

Agro-Industry

The need to train the agricultural engineers to have skill in agro-industries is keenly felt. The latest development of chemical technology has a direct bearing in its application to agricultural processing. The processing phases of size reduction, sorting and grading, dehydration, distillation, fermentation, etc, are some of the aspects which are at present absent to the desired level in the agricultural engineering curriculum. In fact, the age old practices of oil ghanis, sugarcane juice extraction and jaggery making processing, sago preparation and turmeric processing still exist in villages. These are to be modernized in the line of modern rice mill or tea processing.

Socio-Economic Needs

Even though it is well known that the population growth is faster, the agricultural labour availability is posing an alarming picture. The charm of agricultural business is vanishing on account of the drudgery involved in the profession. The different aspects like industrial growth, educational level, transportation facilities, civilization and standard of living are fast changing in the country. Its impact is visible in the alarming growth of metropolitan cities. But the village field, yet displays the unchanged farmer with his country plough behind a solitary plough. The farmer has to be lead to other allied occupations. Poultry or dairy business should be an additional business to a farmer who depends on rain - God for his agricultural success. The agricultural engineer will have to create a situation in a village where a farmer will not dread to take up additional occupation for fear of marketing or return. Hence a skill of management is also to be imbibed in the agricultural engineering curricula. This will enable the engineer to start a co-operative enterprise with the help of the farmers of the region. The tact to convince the farmer and to link him with financing institution together with feasibility study report can be inculcated with appropriate curriculum development.

FUTURE NEEDS OF AGRICULTURAL ENGINEERING MAN POWER

Three levels of agricultural engineers are required in future. The agricultural engineer of the lowest level should have the skill to do field and workshop jobs. The training should not only be in the workshop practices, but also on chemical engineering and biological sciences. The second level of agricultural engineers should have enough skill to plan and programme the work of village, to implement the field operation and to repair and service the farmers' equipment. This type of training should create enough confidence in the minds of engineers to own a fleet of farm equipment or to run a repair workshop. Such a situation will promote the opening of spare-parts shops in villages and thus change the look of the villages. The top level training is to generate two types of personnels. This will either fit in research and development or in consultancy. Besides these regular educational programmes, there should be additional training of three different categories. They are:

a) Farmer's training programme for improved water management and machinery utilization

b) Enterpreneur's training programme for appraising of the potentials and prospects of certain promising agricultural machinery

c) Quality improvement programme for those who are working in universities and teaching institutions.

These programmes should be different from what it is existing today. These should be missionary type. On completion of such training, the participant should be enthused to adapt what they have learnt. These training could be possible only through well-qualified and effectively - trained and experienced personnel. Thus the future manpower to cater the needs of the changing society warrants a different training base where the education method is different from that which prevails in the existing pattern. The co-ordination of these levels of personnel to serve the rural community will raise the standard of living of the society besides raising the national income either directly or indirectly.

NEED TO CHANGE ATTITUDE

The future education of the engineers of non-conventional type involves the need for radical change in the attitude of farmers and enterpreneurs because so far the role of conventional engineers is only of service nature whereas the role of emerging specialized engineers is to create motivation. Unfortunately or fortunately the Indian farmer does not want to give up his traditional practice unless he is convinced of the position and utility of the alternatives. Similarly, the enterpreneurs would not like to take a risk in venturing a non-conventional trade at their risk unless they are assured of sustained market. Again the situation in our country, as far as agriculture is concerned is very peculiar. We have a lot of paradoxes. Country plough and tractor operated machinery go hand in hand. Mechanical gadgets find their rapid way in certain post harvest operations even though the farm labour is in abundance. The farmers are prepared to purchase costly equipment like threshers even though they are hesitant to pay a few rupees to go in for Melur plough. The fragmentation of holdings has not retarded the trend of tractor production. Similarly, the low technical level of village industry co-exists with the modern technology of production engineering or powder metallurgy. The traditional village smithy thrives even in the midst of sophisticated forging shops. Inspite of all these, the chain is not complete for want of certain missing links. Consumer satisfaction is not considered in marketing the products. The psycho-socio-economic part of the farmer is another criteria which also has not been properly recognized. The farmers' need for a gadget has to be met with immediately. This implies that the machinery should be in showroom. But the enterpreneurs don't want to block the money in showroom. Thus a point of convergence is not feasible between the consumer and seller. Whenever a farm power is found to be under repair for want of spare parts the farmer has to procure the same from the neighbouring cities. This implies waste in time and energy. Such situation arises for want of spare parts in villages. Such psychological apprehensions deter the farmers from taking up mechanization. As the cycle repair shop exists in each village, there should be farm machinery repair shop. This could be established only if customers are assured of both spare parts and quick service facilities. Hence the attitude of the farmers and artisans are to be properly built up to accept the need for service facilities and implement service utilization in villages. The coordination of three tier set up will induce such an atmosphere.

The engineers trained in the institutions should bear in mind the need of the farmers and utilize the knowledge and skill for the benefit of this community. The training should be oriented towards the goal of improving the living conditions of the rural masses. The courses in Agricultural Engineering education should be modified to suit the needs of the regions/area.

GAP THAT EXISTS

There is a big gap in the trained agricultural engineers to rely on their skill to establish a tractor repairs or implement maintenance shop; between the agricultural engineering training and farmers' acceptance of the agricultural engineering practices; between the young enterpreneurs and the goods available for delivery with the agricultural engineers; in co-ordination between production, marketing, management and extension; in supply and demand of agricultural engineering goods; in an organized machinery to moniter the effectiveness of the agricultural engineers in production and design fields; in identifying or delineating the zone of agricultural engineering and of other engineering area; etc. An element of industrial engineering and appropriate extension drive are the big gaps that are found in the existing curriculum. There is an urgent need to re-examine the education system and effect remedial measures.

TABLE 1 PROPORTION OF CURRICULUM COMPONENTS FOR UNDERGRADUATE AGRICULTURAL ENGINEERING IN USA (Percent)

University	Humanities	Basic Science	Agricultural Science	Basic engineering	Agricultural engineering
Tennesse	17.84	24.88	8.45	22.54	26.29
Mechigan State	20.00	26.50	10.50	24.40	78.60
Iowa State	12.68	28.16	7.98	21.60	29.58
Texas	18.75	22.92	11.11	20.83	26.39
Illinois	16.33	23.13	10.20	19.05	31.29
Geergia	15.13	31.70	2.93	23.90	26.34
California	11.62	24.80	4.65	27.91	31.02
Lousinana	15.00	25.72	5.00	23.57	30.71
Missouri	17.36	30.56	7.64	13.89	30.55

ANNEXURE

AGRICULTURAL ENGINEERING INSTITUTIONS IN INDIA

1. Punjab Agricultural University, Ludhiana (Punjab).
2. Indian Agricultural Research Institute, New Delhi
3. G B Pant University of Agriculture and Technology, Pant Nagar (U P)
4. Allahabad Agricultural Institute, Allahabad (U P)
5. University of Udaipur, Udaipur (Rajasthan)
6. Jawaharlal Nehru Krishi Vishwa Vidyalaya, Adhartal, Jabalpur (M P)
7. Indian Institute of Technology, Kharagpur (West Bengal)
8. Orissa University of Agriculture and Technology, Bhubaneswar (Orissa)
9. Punjabrao Krishi Vidyapeeth, Akola (Maharashtra)
10. Mahatma Phule Krishi Vidyapeeth, Rahuri (Maharashtra)
11. Tamil Nadu Agricultural University, Coimbatore (Tamil Nadu)
12. Agricultural Engineering Institute, Raichur (Karnataka).

TABLE 2 APPORTIONING OF CREDITS FOR VARIOUS SUBJECTS IN AGRICULTURAL ENGINEERING CURRICULUM OF VARIOUS AGRICULTURAL ENGINEERING COLLEGES IN INDIA

Subject	OUAT Bhubaneswar	PAU Ludhiana	Udaipur	UPAU Pantnagar	IIT Kharagpur	JNKVV Jabalpur	TNAU Coimbatore	Average weightage (%)
Humanities	9%	4%	3%	7%	11%	7%	7%	7
Basic Sciences	28%	15.5%	24%	17%	30%	30%	19%	23
Agricultural Sciences	15%	14%	13%	8%	11%	11%	22%	13.5
Basic Engineering	27%	40%	28%	35%	23%	25%	22%	29
Agricultural Engineering	21%	26.5%	32%	33%	25%	27%	30%	27.5

FUTURE TRENDS IN METALLURGY AND MATERIALS EDUCATION

Dr G S Upadhyaya*

INTRODUCTION

The purpose of metallurgical education is to prepare people competently to perform one or more of the following functions[1]:

(a) To control the efficient and economic extraction, production, recovery, manufacture and fabrication of metals, their alloys and other allied engineering materials to obtain optimum properties in the finished product.

(b) To work closely with engineers at the design stage.

(c) To study, predict and monitor the behaviour of metals and other materials in service.

(d) To undertake responsibility for control of quality in finished products.

(e) To manage and direct operations concerned with the many applications of metals and related materials.

Professor Richardson[2] very justifiably divided the scope of metallurgy into two sectors——one basic and other applied. The basis was further divided into three sub-sectors namely, Physical Metallurgy, Chemical Metallurgy and Process Science. The last one, that is, process science concerned with fluid mechanics, and heat, mass and momentum transfer. It is impossible to attempt any quantitative treatment of metallurgical process without drawing on the principles of process science. It is regretted that present metallurgical education in India is not taking full advantage of process science, with the results that metallurgical engineers coming out of universities and institutes are not fully conversant and the major show is rightly done by chemical engineers. Apart from this, the education of process science is a costly affair, nevertheless some national institutions should come up to the expection.

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There has been some added input in R&D in this area, but unfortunately the manpower for this challenging job is rather negligible. It is hightime the metallurgical educationists looked into this matter, before it is too late. The need for higher productivity in metal industries has presented various interesting propositions like raising temperature, manipulating pressures to high or low value, closer control of size and composition of material fed into a plant and increasing surface area, for example, use of porous or finely divided solids. Pollution problems in metallurgical industries have further added in the significance of process science. The choice of metallurgical process, the location for a commercial plant or even the decision to proceed with an otherwise attractive venture may swing upon the technical and economic feasibility of the processes that can be used to control the scources of pollution.

Coming to the applied sector of metallurgy, the same was classified into three sub-sectors, namely materials (covering physical metallurgy and chemical metallurgy), extractive metallurgy (covering process science and chemical metallurgy) and mechanical metallurgy (covering process science and physical metallurgy).

Physical metallurgy centered on simple theories of crystal lattice structure and of dislocation, nucleation, transformation and diffusion. The precise measurement of the atomic lattice parameters in solid solutions and intermetallic compounds permitted a major contribution by Hume-Rothery and his school, who developed semiquantitative descriptions of alloying of iron in terms of atomic size factors, electrochemical effects and electron/atom ratios. According to Morris Cohen[3] 'metallurgy provides an information-transfer network which channels scientific discovries out to the needs of society; but no less important is the fact that metallurgy conducts empirical knowledge from society back to science'. For metals in particular and materials in general, the above knowledge conduction band was protrayed operationally as a system of linkages

Structure/Property/Performance/Processing

In this representation, fundamental understanding flows from left to right, while the requirements and experience of society penetrate from right to left. According to Cohen[3], this unidirectional conception is unrealistic, if not fallacious, in a discipline like metallurgy, and tends to inject a hierarchy into the field which is neither warranted nor helpful. The warning by Professor Cohen is equally valid in the field of metallurgical education.

In brief the objectives of metallurgy and materials science must be

(a) to import understanding of fundamental scientific and engineering principles and the knowledge of materials and processes which will form the basic for a satisfying career.

(b) to stimulate appreciation of the wide issues of materials and of engineering design outside the immediate professional experience.

(c) to fit people to work with others of different professional skills in the achievement of corporate objective.

(d) to ensure that individuals are sufficiently flexible to meet changes in science and technology throughout their working lives.

TEACHING METALLURGY AND MATERIALS SCIENCE

The science and technology of metals and materials must be taught bearing in mind the needs of the materials-producing and materials-using industries. It is no good to teach the science and technology of materials in isolation from consideration of the properties of other engineering materials. This imposes more stringent demands on our courses, which should cover both metallics and non-metallics. The students must develop an appreciation of how and why other materials differ from metals in their properties and why and in what circumstances they may be preferable to metals. The undergraduate course cannot accommodate all the knowledge required by a competent practising metallurgist. Further specialization is a must and industry must encourage this. Unfortunately, in this country, with few exceptions, industry is neither equipped nor willing to provide attractive education and training for the new graduates, with the result that they get disillusioned soon. Professional institutes like Indian Institute of metals can serve this cause substantially by collaborating with all organizations responsible for imparting metallurgical education. It is surprising that their existing causes are not much different from the normal university courses, though the examinees are mostly service technicians. The courses must be designed specifically to meet identified industrial and national needs. Some countries particularly Sweden is experimenting in introducing case studies courses, so as to bridge the gulf between the newly qualified young engineer and the industrialist. At Chalmers University of Technology[4], the course is based on industrial work, with assigned projects instead of formal lectures. Some categories are like application of new materials, development of existing technology, and failure analysis. The students carry out a metallographic analysis, possibly backed by chemical, x-ray and microprobe analyses, as well as mechanical testing. The inter-disciplinary nature of the course makes it fairly demanding one for both teachers and students alike.

AN ENGINEERING APPROACH TO MATERIALS SCIENCE

Though in recent years great advances have been made in the teaching of materials science to engineers, there remain, however, some strong criticisms of the present materials engineering courses. The courses are inadequate in their coverage of[5]:

(a) the behaviour of real engineering materials in real service environments.

(b) the production engineering aspects of materials processing.

(c) the economic factors which enter into materials selection and design.

(d) the engineering mechanisms of service failure

(e) the sources of data on materials and the handling of such data for design purposes.

(f) the nature of the testing programmes which must necessarily be undertaken, ranging from the testing of specimens to components and finished assemblies.

Our experience on the graduates in Materials Science, has shown that they are too introspective. To mitigate this shortcoming, there needs to be much more emphasis on materials engineering. The educators of materials engineering, have to be partially blamed for the lack of fulfilment of the purpose. The Government is also so far not much concerned with such shortcomings. The solution, in the interim period, lies in inviting lecturers from industry with specialist experience of the interplay between materials and design. Post graduate courses should be specifically designed to encourage students to consider new and improved materials which are often neglected for considerable periods for a variety of reasons---conservatism, unfamiliarity with their processing, inadequate information on over-all costs, lack of experience in fabrication, etc. On the other hand employers must give greater encouragement and incentives to graduates to take post graduate courses on materials engineering and design.

ACADEMIA-INDUSTRY INTERACTION IN METALLURGY

Within recent years there have been some trends in favour of increased academia-industry interaction, but the main trouble is that they are short lived. To solve this, we must start with the assumption that neither side is perfect. Universities and institutions are still burdened by science, which distorts the relative role of engineering inside the institute and works against academia-industry interaction. Lately some disillusions have crept in the mind of academics. Questions like, of what use is the work, we are doing? Are now being asked, and these questions were not asked ten years ago. On the education side, the time has come to introduce internship with industries. This would convince the students that academic work after some experience in industry is far more relevant and thus more effective in serving our educational goals. On the industry side there ought to be a sympathetic supervisor, who should recognize that the role of student is one of concentrated learning as well as engineering practice. We should see that the student takes part in the engineering decisions that accompany the period of internship. The student must submit a proposal describing the problem area as he sees it and the approach selected to solve the problems.

FUTURE OF METALS AND MATERIALS-RECOVERY AND RECYCLING

Every country is concerned about metal resources in relation to what one thinks of as commercially viable ores. Commercially viable is related to what one can afford to look upon as reasonable to pay for the extracted metal. With the sharp increase in the cost of energy since 1973, much attention has been given to the energy required to get materials into usable forms. One of the solutions is in substitution and the critical uses of metals. For examples primary cobalt has applications in magnets, super alloys, cemented carbides, tool steels catalysts, pigments and metal-organics[6]. In this, some substitution could be made in permament magnets, though, cobalt as a binder for tungsten carbides could not be replaced easily. In general, it can be said that about one-third of the use of cobalt is critical to that metal, whilst with two-thirds, substitution could take place. The future metallurgical education would naturally be focussed in identifying the critical uses of metals and not to wait for metal resources to become almost exhausted.

A further possibility for conserving scarce diminishing metal resources is by recovery and recycling. For example zinc and tin coating cannot go idefinitely. In other words our future education pattern should include informations favouring the use of alloys or composites which enable the relatively scarce metals to be readily recycled. In the use of metals in future one should be more resource-conscious and perhaps less cost-and fitness-for-purpose conscious[7]. The above philosophy is nevertheless difficult to convince among some big industries and enterprises. Another real difficulty that the world is going to face is in relation to metal use versus growth of world population, coupled with the increasing hopes and aspirations of the developing nations. The sea bed is likely to become a seriously exploited source of metals in the near future. A good example is 'manganese nodules' which are rich in variety of metals apart from manganese.

The development of such new mineral resources would demand new sources of energy for efficient extraction of metals out of them. The conventional commercial energy sources in India - oil, coal and hydro-electric power - may have their limits. Obviously a new pattern of energy production is essential. Material aspects of energy conversion would certainly be acute. Magnetohydrodynamic power would demand development of new high temperature materials. Similar would be the problem in coal liquefaction.

In conclusion one would certainly be proud of a bright future of metallurgy and materials education, if the Indian educators, government and society are all alive with the problem of metals and materials resources and their optimum exploitation within the constrains.

REFERENCES

1. Anonymous, The metallurgist and materials technologist, April 1978, p 194.

2. F D Richardson, 16th Hadfield Memorial lecture, Journal of Iron and Steels Institute, Vol 203, March 1965, p 217.

3. M Cohen. 'Metallurgy in Metamorphosis in Physical Chemistry in Metallurgy' (Ed R H Fisher, R A Oriani, E T Turkdogan), US Steel Corporation, Monroeville, 1976, p 500.

4. K E Easterling and H F Fischmeister, Metals and Materials, Vol 7 No 10, October 1973, p 452.

5. Anonymous, The Metallurgist and Materials Technologist, Vol 10, No 1, January 1978, p 13.

6. E T Hayes, Superalloys: Metallurgy and Manufacture, Proceedings of Third International Symposium, September 1976, Claitors Pub Div, Louisiana, USA, 1976.

7. J Nutting, Presidential address, The Metals Society, 1977, Metals and Materials, July/August 1977, p 30.

INCLUSION OF SYSTEM THEORY AS CORE SUBJECT IN ENGINEERING CURRICULUM

J Pal*

FIELD REQUIREMENTS

Let us first explore the task, an engineer may have to face after graduation. He may have overall responsibility for the evolution of a complex system, in which case he needs to have an exceedingly good knowledge of creative individuals as well as physical phenomena; he may be a key member of a team concerned with certain aspects of a new development; he may work alone on a new development, new idea, device or subsystem; or he may be responsible for the proper operation and maintenance of a system or subsystem. In all the above cases a proper knowledge or background in system engineering will go a long way in ensuring that the best of the present-day available techniques have gone into any of the stages of design, implementation, extension, operation or maintenance of the particular system in question.

COMMON ASPECTS OF SYSTEM THEORY AND TRADITIONAL ENGINEERING CURRICULUM

Many of the mathematical pre-requisites for system theory are found to be covered by the engineering curriculum in most of the universities. Recent text books on system theory[1-4] invariably contain the subjects of transfer function, Fourier, Laplace transform analysis, state space analysis, stability theory, optimization techniques, set theory, and others. Most of the above subjects are included in the engineering course in one form or the other. The present trend, in having control systems included in the under-graduate level as a compulsory subject just proves the point that most of the basic pre-requisites of system theory are already being taught under the Engineering curriculum.

APPLICATION OF SYSTEM TECHNIQUES IN ENGINEERING DISCIPLINES

System theory, system technique or system approach - the various coinages that we have of the same subject - has been extensively applied and implemented in the various disciplines of an engineering course.

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Mathematical methods such as the Laplace, Fourier transforms and concepts of transfer function have been an integral part of an engineering curriculum and find applications in machines, power systems, network analysis, control systems, electronic analysis, and communications. The modern techniques of state-space representation and analysis, optimization techniques, sensitivity analysis, programming (dynamic etc) have already been applied in almost all spheres of different engineering disciplines. The conception of these modern techniques may basically be traced to control systems and network theory which are as such, accepted as basic subjects in many engineering curriculum.

The various disciplines in which system theory has been applied are listed below:

Electrical Machines and Devices

State variable formulation, transfer function[1] of electromagnetic devices has been extensively used in analysis (performance, stability etc) and design. Signal flow graphs and variational principles have also been used[5]. Non-linear programming has been used for optimization of motor design[6], and digital computers used for electrical machine design[8].

Power Systems

State-space approach has been applied for modelling, analysis and design of electric power system[10, 11]. Classical techniques, eg, root locus method[11], as well as modern variational calculas methods of optimal control[13] have been used in the design of power stabilizers. Linear and non-linear optimisation techniques[14], integer programming[15,16] quadratic programming[17], dynamic programming[18] etc have been used for optimising performance, generator scheduling, power dispatch, transmission planning etc. Estimation and stochastic filtering techniques have been extensively used for parameter identification[19,20].

Communications

Optimal estimation techniques have been applied to communication systems[21,22]. Variational techniques have been applied in communications, optimum filter design[23]. Mathematical methods have been applied in PCM input signal design[24].

Electronics & Computers

Mathematical programming techniques have been applied in solving problems involving digital computer wirings, ray tracing by computers, design of transistor amplifiers, pattern recognition[24]. Integer programming has been used in the design of optimum logic network and threshold logic[25].

Reliability Theory

Flow graph techniques have been used in reliability estimation[26]. Dynamic Programming, allocation, geometric programming, 0-1 programming, etc have been extensively used in reliability and optimal design. Reliability theory has been extensively applied in energy systems, power systems, nuclear aerospace systems and communication systems[27-33].

APPLICATION OF SYSTEM TECHNIQUES TO REAL-WORLD PROBLEMS

With the advent of modern high-speed digital computers, the growing understanding of dynamics of a wide variety of real-world problems that may be classed as societal systems and with the present trend of integrated approach towards such large-scale problems, we find the increasing involvement of engineers in the solution of such problems using system techniques. This is so as the same techniques of system engineering are applicable in arriving at the best solutions for societal problems.

Below are listed some of the areas where system techniques are being increasingly used.

Medical Applications

Much inter-disciplinary work has been done in the field which goes by the name of Bio-engineering[34-37]. System techniques have been applied to modelling and analysis of human sub-systems and in the designing of artificial assisting devices. Identification techniques have been applied in problems of medical diagnosis and other related problems[38]. System techniques have been used in management problems associated with health-care facilities[39,40].

Urban Problems

Multivariable programming and variational calculus methods have been applied to various urban problems like transportation, urban dynamics, solid waste collection/disposal etc[41-45]. Optimisation of investments in highway networks[51]. Vehicle scheduling, loading and the determination of fleet size etc[52]. An hierarchical system formulation for urban systems[58]. A collection of some examples of how modern systems analysis techniques are applied to a wide variety of real-world problems - water resources analysis (8 cases), transportation, analysis (7 cases) and power generation, solid waste collection, soil engineering and product development[55].

Agricultural Systems

Control techniques have been applied in agricultural system e.g. tractor design and guidance systems, irrigation and spraying, harvest automation, agricultural production, dairy and livestock production[56]. System analysis has been particularly applied to Agricultural management[57]. A multi level approach to agricultural problems[58]. System techniques have been extensively applied to water management and water resources problems[58-61].

Economic Systems

Optimal feedback control has been applied to the regulation of a macroeconomy and Kalman filtering techniques to several areas of economics[62, 63, 64]. Stochastic and non-linear techniques have been applied for modelling and analysis of Econometric Systems[65]. Optimization techniques have been applied[66].

Environmental Systems

With the growing world-consciousness regarding pollution and ecological equilibrium several applications of systems techniques in the area have also appeared[67,68]. Programming techniques, optimal control theory has been extensively used for pollution control[69-72].

A sample survey of the areas in which system theory has been applied is given above. However, it must be emphasized that the references quoted are just for demonstrating the all encompassing nature of the field of application of system theory and are in no way exhaustive.

CONCLUSION

The relevance of system theory to future engineers has been conclusively established through a current literature survey. It is suggested that the subject systems theory be included in the under graduate curriculum of an Engineering course as a compulsory subject. At the post-graduate level proper emphasis should be given to relevant topics that fall in the area of concerned specialisation.

REFERENCES

A. System Theory

1) L A Zadeh and C A Desoer. 'Linear System Theory'. N Y, McGraw Hill, 1963.

2) L A Zadeh and E Polak. 'System Theory'. N Y, McGraw Hill, 1969.

3) J G Truxal. 'Introductory System Engineering'. N Y, McGraw Hill, 1972.

4) R E Kalman, P L Falb and M A Arbib. 'Topics in Mathematical System Theory'. N Y, McGraw Hill, 1969.

B. Electrical Machines & Devices

5) S A Nasar. 'Electromagnetic Energy Conversion Devices & Systems'. Englewood Cliffs, N J Prentice - Hall, 1970.

6) R Ramaratnam and B G Desai. 'Optimisation of Poly-phase Induction Motor Design - A Non-linear Programming Approach'. Trans IEEE (PAS) Vol 90, 1971, p 570.

7) A V Berger. 'Selection of Optimum Value for Air-gap in Induction Motors'. Bulletin of WZOF - Energtica, No 6, 1966, (in Russian).

8) R M Saunders. 'Digital Computers as an Aid in Electrical Machine Design'. AIEE Trans Vol 73, Pt 1, 1954, p 189.

9) J F Szablya and J M Bressane. 'Transfer Function of AC Machine'. Trans. IEEE (PAS), vol 92, Jan/Feb 1973, p 177.

C. Power Systems

10) O I Elgerd. 'Electric Energy Systems Theory'. N Y McGraw Hill, 1971.

11) A H El Abiad and G M Staff. 'Computer Methods in Power System Analysis'. McGraw Hill, 1968.

12) K Bollinger, A Laha et al. 'Power Stabilizer Design using Root Locus Methods'. Paper C 74-424-8, Summer Power Meeting, 1974.

13) A Rajagopalan and M V Hariharan. 'Bangbang Excitation Control'. Trans. IEEE (PAS) Vol 93, No 2, March/April 1974, p 703.

14) A R Daniels, D H Davis and M K Pal. 'Linear and Non-linear Optimisation of Power System Performance'. Trans. IEEE (PAS), Vol 94, No 3, May/June 1975, p 810.

15) K B Misra. 'Optimum Reliability Design of a System Containing Mixed Redundancy'. IEEE Trans on PAS, Vol 94, May-June 1975, p 983.

16) J F Dopazo and H M Merrill. 'Optimal Generator Maintenance Scheduling using Integer Programming'. Trans IEEE (PAS), Vol 94, No 5, Sept/Oct 1975, p 1537.

17) H Nicholson and M J H Sterling. 'Optimum Dispatch of Active and Reactive Generation by Quadratic Programming'. Trans IEEE (PAS), Vol 92, No 2, March/April 1973, p 644.

18) V P Dusonchet and Ahmed El-Abiab. 'Transmission Planning using Discrete Dynamic Optimizing'. Trans IEE (PAS), Vol 92, No 4, July/Aug 1973, p 1358.

19) F C Schweppe and J Wildes. 'Power System Static-State Estimation, Pt I (pp 120-125), Pt II (pp 125-130)'. Trans IEEE (PAS), Vol 89, 1970.

20) F Ariatti et al. 'Methods for Electric Power System State Estimation'. Proc 4th PSCC, Grenoble, 1972.

D. Communications

21) A P Sage and J L Melsa. 'Estimation Theory with Applications to Communications and Control'. N Y, McGraw Hill, 1971.

22) A J Viterbi. 'Principles of Coherent Communication'. N Y, McGraw Hill, 1966.

23) J B Thomas. 'Statistical Communication Theory'. N V, Wiley, 1969.

24) M Aoki. 'Introduction to Optimisation Techniques'. N Y, McMillan 1971.

25) S Muroga. 'Threshold Logic and Its Applications'. N Y, Wiley 1971.

E. Reliability Theory

26) K B Misra and T S M Rao. 'Reliability Analysis of Redundant Networks using Flow Graphs'. Trans IEEE (Reliability) Vol 12, Feb 1970, p 19.

27) K B Misra. 'On Optimal Reliability Design : A Review'. Invited Paper by IFAC for 6th World Conference Boston, Mass, USA, Aug 1975.

28) K B Misra. 'Optimum Reliability Design of a System Containing Mixed Redundancies'. Trans IEEE PAS-Vol 94, No 3, May/June 1975, p 983.

29) K B Misra. 'Reliability Design of a Mixed Redundancy System'. Kernenergie, Berlin, 18, Jahrgang, Heft 1, p 22, Jan 1975.

30) K B Misra and E Balagurvsamy. 'Reliability Analysis of K-Out-of-M: G Systems with Dependant Failures'. I J of Systems Science (accepted for publication)

31) G W A Dummer and N B Griffin. 'Electronics Reliability Calculation and Design'. Pergamon Press, 1966.

32) R Billinton. 'Power System Reliability'. Gordon and Breach, N Y, 1970.

33) A M Polovko. 'Fundamentals of Reliability Theory'. N Y, Academic Press, 1968.

F. Medical Applications

34) J H Milsum. 'Biological Control Systems Analysis'. N Y, McGraw Hill, 1966.

35) Robert Plonsey and D G Fleming. 'Bioelectric Phenomena'. N Y, McGraw Hill, 1969.

36) William B Blesser. 'A Systems Approach to Biomedicine'. McGraw Hill, 1969.

37) G H Myers and V Parsonnet. 'Engineering in the Heat and Blood Vessels'. Weiley-Interscience, 1971.

38) A Cohen. 'Parameter Estimation for Medical Diagnosis'. In IFAC Identification and System Parameter Estimation Symposium, Part 1, Amsterdam 1973.

39) A K C Wong and T Su. 'Regional Planning of Health Care Facilities'. IEEE Trans on Sys Man Cyber, Vol SMC-3, No 5, Sept 1973, p 485.

40) G S Lasden. 'Planning the Delivery of Out-patient Service using Simulation'. ibid, p 508.

G. Urban Problems

41) M D Mesarovic (Ed). 'Systems Approach and the City'. American Elsevier, N Y, 1973.

42) R Bellman and C P Smith. 'Simulation in Human Systems'. N Y, John Wiley, 1973.

43) Ida R Hoss. 'Systems Analysis in Public Policy'. Acritique University of California Press, 1972.

44) J W Forrester. 'World Dynamics'. Wright-Allen, Cambridge, Massachusetts, 1971.

45) J G M Cuypers. 'World Dynamics, Two Simplified Versions of Forrester's Model'. Automatica, Vol 9, 1973, p 399.

46) J W Forrester. 'System Analysis as a Tool for Urban Planning'. IEEE Spectrum, 8, Jan 1971, p 48-

47) A P Sage. 'An Editorial'. IEEE Trans on Sys on Man Cyber 2, 1972, p 121. N B: The entire issue containing this editorial is concerned with the study of urban systems via simulation modelling.

48) D Tabak. 'Application of Modern Control and Optimization Techniques to Transportation Systems'. In Control & Dynamic Systems, Vol 10, Leondes, C T (Ed) p 345 , N Y, Academic Press, 1973.

49) G Chadwick. 'A Systems View of Planning : Towards a Theory of the Urban and Regional Planning Process'. Oxford Pergamon Press, 1971.

50) J B Mc Loughlin. 'Urban and Regional Planning - A Systems Approach'. London, Faber and Faber, 1969.

51) P A Steenbrink. 'Optimization of Transport Networks'. London, John Wiley, 1974.

52) Samuel Eilon, C D T Watson, et al. 'Distribution Management - Mathematical Modelling and Practical Analysis'.

53) D A Wismer and R E Larson. 'A Hierarchical System Formulation for Urban Systems Engineering'. Session on National, Regional and Urban Systems, 5th World Congress of IFAC, Paris (1972).

54) D A Wismer (Ed). 'Optimisation Methods for Large Scale Systems with Applications'. McGraw Hill, N Y, 1961.

55) Richard de Neufville, David H Marks (Ed). 'Systems Planning and Design, Case Studies in Modelling, Optimization and Evaluation'. Englewood Cliffs, N J Prentice Hall, Inc, 1974.

H. Agricultural Systems

56) Preprints 1974 IFAC Symposium on Automatic Control for Agriculture, Saskatoon, Canada.

57) J B Dent and J R Anderson (Ed). 'Systems Analysis in Agriculture, Management'. John Wiley, Sydney (1970).

58) J Pal and L M Ray. 'A Multi-level Approach to Integrated Agrosystem Design'. Preprints National System Con India, Roorkee, 1976.

59) W A Hall and J A Dracup. 'Water Resources Systems Engineering'. McGraw Hill, N Y, 1970.

60) Y Y Haimes. 'Hierarchical Modelling of Regional Total Water Resources Systems'. Automatica, Vol 11, No 1, Jan 1975, p 25-

61) M M Shah. 'Systems Engineering Approach to Agricultural and Rural Development Systems'. In Computer Simulation of Water Resources Systems (Ed). G C vansteenkiste, p 865- , North-Holland, Amsterdam (1975).

I. Economic Systems

62) K P Vishwakarma. 'Macro-Economic Regulation'. Rotterdam : Rotterdam Univ Press, 1974.

63) G C Chow. 'Analysis and Control of Dynamic Economic Systems'. N Y, Wiley, 1975.

64) Robert S Pindyck. 'Optimal Planning for Economic Stabilization'. North Holland, Amsterdam 1975.

65) J Phillip Cooper and Stanley Fischer. 'A Method for Stochastic Control and Non-linear Econometric Models and an Application'. Report 7319, Centre for Mathematical Studies in Business and Economics, University of Chicago, Illinois (1973).

66) R Dorfman, P Samuelson and R Solow. 'Linear Programming and Economic Analysis', McGraw Hill, 1958.

J. Environmental Systems

67) Linvil G Rich. 'Environmental Systems Engineering'. McGraw Hill, 1973.

68) B C Patten (Ed). 'System Analysis and Simulation in Ecology'. Academic Press, Vol I (1971) Vol II (1972) N Y.

69) J R Marsden et al. 'Application of Nonlinear Programming to Water Quality Control'. Water, Air & Land Pollution, Vol 2, No 2, June 1973.

70) C W Winn and J B Moore. 'An Application of Optimal Linear Regulator Theory to a Problem on Water Pollution'. IEEE Trans Man & Cyber, Vol SMC-8, No 5, Sept 1973, p 450.

71) R Kulikowski. 'Modelling and Optimum Control of Complex Environment Systems'. Control & Cybern. (Poland), Vol 2, No 1-2, p 15, 1973.

72) P C Young, M B Beck and M G Singh. 'The Modelling and Control of Pollution in a River System'. Proc Symp on Water Resources Systems, Haifa (1973).

PRINCIPLES OF EDUCATING ENGINEERS OF FUTURE

S N Sharma*

INTRODUCTION

Important changes have taken place during the last 25 years, which might affect engineering education in future. Science and technology have become an integral part of every phase of society. Engineers responsible for the efficient use and organization of its resources, both natural and industrial, as well as human have become the back bone of the country. They seem working in every walk of life. Both defence and development depend upon their quality and quantity. The scientific and technical knowledge, useful to them, has more than doubled in this short span of human history. Engineering research has become highly specialized and mathematical. Therefore, engineering education in this country has to be modified to keep pace with development abroad and also to suit the bullock cart age in villages. Thus engineering education in future India has to be based on the concept of appropriate technology. Course objectives of every phase of engineering education has to be clearly stated, and curriculum development programme has to be based on these objectives.

TRAINING MODULE FOR SECONDARY BOYS

Some type of engineering education has to be started at the age of 14 years, when the student takes Science and Mathematics as optional subjects. The elementary skills have to be developed at this age. The students are being taught the fundamentals of science and mathematics but emphasis is not given on development of basic skills. India mainly being an agricultural country where 71% of its population is engaged in agriculture, the secondary schools have also to play, the new role of introducing, the future young engineers to the world of technology by training them in basic skills. The use of hand and measuring tools is basic skill which is useful to every engineer irrespective of the branch of engineering. Such essential operations which are useful to engineers could be identified and a module could be prepared. Elementary plumbing and electricians' work limited to minor repairs of installations and house hold utility items could also form part of this module. It is difficult to develop such a training programme in the first instance which fully satisfy the needs of time but some beginning has to be made. This module could be reviewed and changed as per the needs of the country in future.

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IMPACT OF TECHNICAL DEVELOPMENT ON ENGINEERING EDUCATION

Some employers in the country expect engineers to deal with all aspects of mechanical civil engineering as the case may be. It makes the employment pattern of this country different when compared to Western Countries, as a result of which a large number of compulsory subjects had to be provided in the curriculum of engineering graduates. In the past to deal with the expansion of knowledge, the only alternative left with Indian engineering educationists was to increase the syllabi in every subject, but over crowding of the time table has its own limitations and there is no scope for it in the future. Another proposal recommended increase in the period of education. Many Institutions have moved in this direction but this does not seem to be the correct solution. The additional year could affect adversely the career of young men who shall enter the profession of engineering. Because of rapid progress in science and technology this now appears to be no solution. One proposal suggested, was bifurcation of the present curriculum into two types of courses to suit operating engineers and design engineers. Moreover in the context of present day development in technology operating engineers and design engineers have to be taught some of the same fundamentals. Therefore, this suggestion has also become old and none of the advanced Countries have adopted it. It is also felt that for immediate job competance it becomes necessary that the standard of admission be raised and specialized knowledge be provided. Narrowing the field of engineering activity and increasing the practical competence at college level could improve the quality of engineers. Engineering institutions in USA prepare in broad fundamentals of engineering. The institutions provide a large number of elective subjects where the students select various groups to suit their choice of future careers. As the Industry is developed in that part of the world, proper training and continued education is the responsibility of the industry. To cater for the future advancements in engineering, students are being educated more in concepts and methods of the scientific and engineering disciplines, that provide the basis for the mounting overburden of particular knowledge. Job oriented education is being provided in Russia. The present difference which exists in the pattern of technical education of these two developed countries is because the pattern of society is different. India has adopted a socialistic pattern of society and pattern of technical education in future shall have to be designed to suit the pattern of society. Again, the advancement of science and technology is afflicting the society of this country also. This process is rapidly gaining importance because each technological solution which society accepts changes the outlook and value system of the society. The operating systems (transportation, material supply, communications) have become extremely complex and interdependent as a result of society's increasing dependence on technology. Moreover, the foreseeable broadening of engineering and its effect on the activities of engineers, have created circumstances so that the engineering institutions of today cannot give the future engineers sufficient knowledge to last throughout the career.

NEW ROLE OF ENGINEERING INSTITUTIONS:

Therefore, engineering institutions must teach future engineers the habits of constant and independent study throughout life. Now the engineering institutes are concerned not so much with teaching specific points of 'ready-made' knowledge as with developing the ability to acquire new knowledge and new techniques; in other words, encouraging the ability to work creatively. With this change the curriculum development programme shall have to be based on modified principles. Addition and subtraction type of changes in syllabi are not going to serve any purpose in future. Undergraduate programme must provide a basic education for those who wished to function as engineer in the broadest possible non-specialized sense to suit all types of engineers, as apprentice engineer, junior engineer, sales engineer, maintenance engineer, assistant design engineer and so on. Many drastic changes have to be made and new kind of programme has to be developed giving reasonable emphasis on intellectual development and evaluative activities. In fifties and sixties engineering education was based on to provide capabilities in operation, maintenance and design of machines, structures, buildings, dams. Now, engineering education shall have to be provided aiming at design of systems including social and human elements. Thus, the future engineer must have better understanding of the world systems and must be able to cope with problems in systems terms and understand the basic principles of engineering. Moreover, the engineering activities in the field of design require a sophisticated, maths-science background. It is established that engineering has its roots in mathematics and basic sciences but carry knowledge further towards its applicability to various systems in engineering analysis, design, and syntheses. To develop competence, the fragmental material now offered in several courses has to be collected and corelated. The principles of thermodynamics, fluid and solid mechanics, dynamics of heat and mass transfer are the same for chemical or mechanical engineering and every kind of engineering. The student once taught the principles of heat and mass transfer can specialize on design and can operate, and maintain cooling systems. He can explain the advantages of cooling system of power plants and chemical plants belonging to different sectors of engineering activity. Similarly, once taught the principles of fluid and solid mechanics at graduate level, it is easy to specialize in hydraulic machines or in air fans. The present ratio of curriculum content of mathematics, basic sciences and technical subjects which is about 80% of the total syllabi could be allowed to remain. However, a large number of elective technical subjects shall have to be provided to meet the requirement of variety of fields.

COURSE CONTENT IN NON-TECHNICAL SUBJECTS

The ethical sense, if properly developed during the educational period, may enable young engineer to distinguish engineering as a noble profession from engineering as a trade. Throughout the country, many engineers are entrusted with the task of executing very many projects. The ethics of their profession is no less important than the technical competence in such works. Therefore in addition to technical competence development of ethical sense is a sacred responsibility which shall have to be shared by the technical institutes in future. The content of the non-technical subject in the field of general education, communication, humanities and social studies should be about 20% of the course content. The contents should be so selected as to develop communication skills and abilities of supervising the activities of craftsmen and technicians who provide support for engineering activities.

COURSE OBJECTIVES

Thus the objectives of the graduate programme could be summarized as follows :

(1) Mastery of the fundamentals of modern science and its applications for an engineering activity.

(2) Development of intellectual abilities to recall, manipulate, translate, interpret, predict and choose, by analyzing, synthesizing and evaluating.

(3) Develop a competence of professional calibre to enter in the profession, so that he may be able to assist senior engineers in engineering activities and in the process of decision making.

(4) Prepare for continued competency by self study.

(5) Grasp of the relatedness of all things contributing to our environment.

(6) Judgement and power to take decisions which lead to solution of technological problems.

(7) Learn communication as an art to control the activities of supporting staff.

(8) Engender awareness of ethical and moral responsibilities.

(9) Develop capabilities to delineate and solve problems of the society.

SUGGESTIONS FOR IMPROVING PRESENT TRAINING ARRANGEMENTS

If the above suggestions are accepted by engineering institutions, effective training arrangement will be a necessity; otherwise engineers so educated may not develop immediate job competence. It has also been accepted that as a result of the existing pattern of society, proper training for engineers, can only be arranged by the combined efforts of the industry, and the institution. With the amendment of the Apprentices Act to include graduate engineers a powerful organization has already been set up for training of graduate engineers. The Apprenticeship Boards in each region are now responsible for making training arrangements for engineers passing out of the engineering institutions. It is also found that at present there is no system of evaluation of the trainees. The sector-wise training programmes have not yet been developed by this organization. The graduate engineers coming out of the college are not guided to understand the basic factors relating to the dynamics of self-development. At all levels of engineering activities certain basic skills and techniques are needed, though the degree of competence in use of these skills vary as per the job requirements. Major skills include the following :

(1) Technical proficiency, which include :
    (a) Intellectual skill.
    (b) Technical knowledge.
    (c) Analytical ability.

(2) Communicative skills.

(3) Motivative skills.
    (a) Personal qualities.
    (b) Human relationship.

It is difficult to identify training skills of every engineer and develop them keeping in view the large number of apprentice engineers. However, the Regional Apprenticeship Boards could provide some guidelines in this respect. A co-ordinated training programme which shall develop immediate job competence is a necessity. It is also felt, that at present the time spent in apprenticeship, is not fully utilized. It is difficult to control and regulate the training of every engineer during apprenticeship but some urgent steps could be taken which may help development of the above skills and result in increased job competence. It is suggested that immediate steps should be taken to prescribe the list of books to be read by graduate apprentice engineers receiving training in each sector of engineering activity. They should be compelled to read these books. Periodical seminars should be organized separately for a group of engineers receiving training in each sector of engineering activity, where the trainee engineers should be given an opportunity to discuss regarding the topics where they receive training. Each trainee engineer should be asked to write a report of the training he undergoes and which should highlight his contribution towards that activity. These reports should be examined at the end of their training and their contribution towards the engineering activity be assessed and nearing the end of the training, employer should give a project to each apprentice engineer. The apprentice engineer should complete the project and prepare a project report. The project report could be evaluated for each group of engineering activity. Thus the engineers should be required to develop their full potential by providing them the necessary facilities for acquiring knowledge and said skills.

EDUCATION AT POST GRADUATE LEVEL

A thorough knowledge of specialized advanced development is essential both for research and industry. The aim of engineering education at post graduate level is the cultivation of the highest level of professional competence, and it is also directed towards the mastery of the engineering science in the concerned field of the engineering activity. Thus the post graduate course is a pre-requisite for research. In future, the Engineering institutions are required to perform three functions, namely, (a) teaching, (b) research and (c) extension. It is felt that the normal growth and development of the research programme should not be allowed to lag behind the institutions educational programme. The research should be on the topics concerning appropriate technology. Technical institutions should give equal emphasis on extension programme. The benefactories could be engineers employed in the industries, government departments or elsewhere. The extension programme of the institutes should act as a means of technology transfer. It is in this field that the engineering institutes in this country are lagging behind, and are selecting research topics which may not be related to appropriate technology in various fields of engineering activities.

CONCLUSION

As a result of engineering and technological advancements change of pattern of technical education at college level is a necessity. The addition and subtraction type of change in the syllabi may not serve any purpose. The subjects which are important for teaching engineering principles may have to be given more importance. The students have to be taught the basic fundamentals of engineering principles and it should be assured, that they develop intellectually. With this change, proper training arrangement after graduation assumes all the more importance. The amendment of the Apprentices Act to include the graduate engineers may not serve the required purpose unless some types of flexible training schedules are prepared for each group of engineering activity. The engineering institutions shall be required to perform three functions, viz, teaching, research and extension work for transfer of technology. The research topics and extension work shall have to be related to appropriate technology.

REFERENCES

1 Engineering is decision making - Teach Thati
Charles E Wales / 278
Engineering Education (U S A) Volume 62, Number 3, December 1971.

2 The professional development of professional Engineers
Philip Marvin/ 450 Further details as at serial No 3.

3 The design of an educational system. Charles E Wales and Robert A Stager / 456, Engineering Education (U S A) Volume 62, Number 5, February 1972.

4 Education for an Engineering Future. H E Hoelscher / 786
Engineering Education (U S A), Volume 62, Number 7, April 1972.

5 Educating for Creativity / Charles R Schrader / 898
Engineering Education (U S A), Volume 62, Number 8, May 1972.

6 Improving communications between industry and University faculties / R J Craig / 50, Engineering Education (U S A) Volume 63, Number 1, October 1972.

7 Young faculty research in an undergraduate college.
Conrad J Hemond, Jr / 263, Engineering Education (U S A) Volume 63, Number 4, January 1973.

PLANNING OF ENGINEERING EDUCATION AN INTEGRATED APPROACH

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INTRODUCTION

In the last three decades, there has been an accelerated growth of scientific and technological knowledge in different spheres, which has caught engineers unawares and caused engineering educational patterns to lag behind technological demands.

The present division of engineering into different disciplines has become outmoded and calls for re-orientation in basic engineering education. Narrow specialization in an increased number of disciplines has also become necessary.

Present engineering education has a theoretical bias, is expensive and therefore available only to the affluent and the brilliant. A large number of potential engineers are not able to study engineering due to high percentages of marks set for admission to Colleges. A critical review of qualitative requirements of training to educate large numbers of engineers and tradesmen on practical lines and evolve training models has thus become imperative.

The guidelines for engineering education should therefore be as follows :

Maximum number of aspirants seeking engineering education should get adequate opportunities. Tradesmen on the job from the lowest echelons should have channels open for educating themselves. Engineering education should be extended to the remotest parts of the country.

Engineering education should have a rural bias, be practically oriented and permit advancement at every level of employment.

Vocationalization should commence early and afford opportunities to learn while earning.

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Educating future engineers is too onerous a task to be left to Engineering Colleges and formal methods of education alone. Industries, Government organizations and professional bodies and local self Government organizations must be fully involved in this process. Non-formal avenues of training through such agencies becomes important. At each achievement level this channel should merge with the formal channel of education.

It is therefore necessary to arrive at formal and non-formal models of imparting engineering education by formulating functional divisions of future engineers and assessing their qualitative requirements.

ENGINEERING PROBLEMS OF 2000 AD

Demands on available resources will increase due to population explosion and an increase in environmental pollution. Engineer tasks in various spheres are likely to be as under :-

Housing

Unconventional building materials may have to be used to reduce the pressure on cement and steel out-put. This will call for a re-assessment and rationalization of existing building codes to permit use of new building materials. Large scale building construction programmes will have to be undertaken in urban and rural areas. Partial and total prefabrication techniques may be necessary on a massive scale.

Energy

Exploration and utilization of unconventional power sources, augmentation of existing thermal and nuclear power potential and optimum utilization of existing water resources will have to be undertaken.

Transportation

Quantum of transhipment of human and general cargo will increase exponentially. A large quantum of awkward loads will need to be transported. Speed of transportation will need to be accelerated.

Ecology

Increased mechanization and enhanced energy consumption will lead to severe environmental pollution. Problems of combating this and disposal of human, industrial and nuclear wastes will assume great importance.

Rural Development

Rural housing, electrification, roads and storage facilities will need large scale expansion. Agro-engineering, techniques for implements and equipment for mechanized farming, de-salinization techniques, water logging and flood control will need to be developed.

GROWING DISCIPLINES

New areas of specilization will become necessary. Need for training large numbers of skilled tradesmen, supervisors and site engineers will become acute. Critical examination of syllabi for basic and Diploma Courses to eliminate irrelevent subjects and modify as required scope of syllabus for other subjects to ensure that training imparted has a useful practical bias is essential.

Urban development and industrial growth will continue simultaneously with rural growth. Future engineering projects will become more complex and will require apart from expertise in engineering, knowledge of applied sciences and humanities such as economics, management techniques, human psychology and man-management. New disciplines and subjects for specilization will emerge. A list of some such specialized subjects is given in Appendix I.

FUNCTIONAL DIVISION OF ENGINEERING

To fulfil the qualitative engineering requirements in 2000 AD, the engineering profession should be divided into different functional categories and engineering education oriented towards their development. At one end of the spectrum will be the engineer tradesman and on the other the engineer scientist. Between these limits will lie other categories as below :-

(a) Skilled Tradesmen
(b) Engineer Supervisor
(c) Site Engineer
(d) Design Engineer
(e) Engineer Manager
(f) Engineer Teacher
(g) Engineer Scientist

QUALITATIVE REQUIREMENTS

Skilled Tradesmen

Very large number of skilled tradesmen in the following two categories are necessary, General Purpose Trades. Trades which require a lower academic background.

Specialized Trades. Trades requiring higher academic background.

Trades like, carpenter, wireman, and driver will fall under general purpose trades whereas artificer, instrument mechanic and surveyor will constitute specialized trades. The level of intake for general purpose trades should be under matriculates to permit development of vocational skills of semi-literate and illiterate youths. Entry into specialized trades may be restricted to matriculation level. A year's training for general purpose trades and two years for specialized trades is necessary to attain a competence level as under :-

(a) To possess knowledge of materials required for the trade and techniques of working with them.

(b) To read simple drawings, make simple stores list and schedule of work.

(c) To know the average out-put and minimum standards of quality required.

(d) Safety precautions commensurate with the trade.

Facility to pass matriculation examination should be made available to such tradesmen.

Engineer Supervisor

Engineer supervisor will be at the level of present foreman in workshops and overseers and sub-overseers in engineering projects. Engineer supervisor should be found from skilled tradesmen. Diploma holders from polytechnics should be eligible to man this cadre as direct recruits. Recruitment from ITI certificate holders with minimum stipulated experience should be permissible. Engineering supervisor will act as a communication link between the basic engineer and the tradesman and should be able to schedule and progress work in his area of jurisdiction.

Basic Engineer

Basic engineer will be at the level of the present engineer graduate. With the predominance of villages, engineering education shall be biased towards rural development. A General Purpose Engineer should be capable of undertaking all complex engineer tasks of 2000 AD which a graduate presently undertakes.

Design Engineer

The total number of design engineers will be much less when compared with other categories. A design engineer should possess a basic engineering degree and should have undergone a specialized course in the particular branch in which his design skills are required.

Engineer Manager

Engineer-Manager should possess a basic engineering degree. He should develop his skills primarily through adequate executive experience. In addition knowledge of managerial subjects is desirable.

Engineer Teacher

An engineer-teacher will be required to hold an academic qualification appropriate to the level at which he is teaching. He should be conversant with modern teaching and communication skills. An academically highly qualified engineer may not necessarily make a good teacher. A prerequisite for an engineer teacher is wide experience in practical problems so that his teaching is always relevant.

Engineer-Scientist

An engineer scientist pursues a narrow specialization in his discipline. He is concerned with the research aspects and would be an engineer interested in advanced technological developments in his area of interest. He should be in touch with the latest developments in his sphere.

TRAINING OF BASIC ENGINEER

Rural bias engineering will involve a lesser degree of sophistication but a higher utilization of local skills at the lowest cost. Engineering works will involve construction of village roads, water supply schemes, permanent and semi-permanent constructions, decentralized sewage disposal systems and electrification works. There will also be structures required for dairy and poultry, farm houses, cold storage facilities and grain silos.

Factual engineering knowledge will be enormous. It will not be possible to teach all available information in the time available. The pattern of engineering education should be planned on developing creative, innovative and self-learning faculties.

Future training should aim at producing the practical learner. This will call for rapid learning and teaching methods, automated and mechanized teaching techniques and visual methods. Discretion has to be exercised in deciding the type of knowledge to be imparted.

Engineering knowledge should be divided into vital, essential and desirable grades. Efficiency of teaching and designing of more efficient programme of engineering education by analysis of specialization at various levels is necessary. Existing engineering curriculum should be modified to orient it towards imparting practical skills. This means inclusion of live situations related to common place engineering problems obtainable on ground. Integrated projects which will involve application of acquired knowledge to a particular problem should be included in large numbers. Curriculum should include visits to projects of engineering interest and submission of project reports. For this purpose close liaison between executive agencies and teaching departments is necessary.

Basic Engineering Degree Programmes

Basic engineering programmes of 2000 AD will be subject to various pressures arising from several factors. The demand to introduce new subjects will increase. Inclusion of greater percentage of humanities, social sciences and management topics into the undergraduate engineering curriculum is necessary.

The duration of undergraduate engineering programme needs to be rationalized and streamlined; simultaneously the content of professional biased specialization needs to be increased. These factors impose such constraints on the planners of engineering education that engineering eduation and training has to be developed as a specialized branch, by itself.

Following model is proposed :-

(a) Develop a 3 to 3½ years basic engineering degree programme mainly oriented towards producing a general engineer with the knowledge of basic scientific and engineering principles on which the engineering world is operating. Only those engineering laws and practices which are not biased to any particular branch of specialization are to be taught. An engineering graduate should have acquired the basic skills to pursue any specialization of his choice. He should be conversant with the social, financial and managerial mechanics of the engineering world. He should have also acquired powerful tools of learning which will ensure his development as a continuous process.

(b) Applied engineering knowledge including project management, field practices, construction procedures, design practices and codes should be taught during basic degree curriculum. For this purpose teaching departments should have access to banks of live problems encountered in practical working. This can be achieved by close liaison with executive agencies.

Proposed Programme

Systems methodology in planning in engineering education is shown in Fig 1 and a proposed programme is shown in Fig 2. The following are its highlights,

(a) Basic engineering degree should not seek specialization but be oriented towards producing a general engineer.

(b) The duration of general engineering degree programme should not exceed 3 to 3½ years after 12 years of basic education.

FORMAL METHOD OF TRAINING FOR OTHER CATEGORIES

Skilled Tradesmen (Certificate Level)

Present division of tradesmen should be enlarged to include new skills like maintenance, operation and repairs of electronic equipment and gadgets; refrigeration, airconditioning and low temperature equipment/devices; telecommunication and remote control units; engineer plants, radios, etc.

Commensurate with the trades concerned matching academic standards are required. Number of tradesmen required will be large; and large number of ITIs will be required in urban and rural areas.

Diploma

Present disciplines of Civil, Electrical, and Mechanical Engineering are too broad to be effective. There should be more types of diploma courses each encompassing more specific subjects, such as Diplomas in Survey, Electronics, Refrigeration and Airconditioning and Engineer Construction Plant. Number of future disciplines should be increased to conform to functional requirements. Extensive workshop facilities are necessary to impart this practical bias. Critical examination of existing diploma syllabus to weed out unnecessary subjects is essential. Even for formal education the active support and participation of industry and other governmental and non-governmental agencies is necessary.

Specialization

After basic engineering, there will be two years specialized engineering training in different disciplines. Specialization will be narrow and deep. This will be after the basic engineer has acquired field experience and has selected a particular subject for specialization with which he is practically associated. Such engineer specialists will be only a few in numbers, and confined only to those who are likely to undertake designs, teaching or research work.

Engineer Teacher

An engineer teacher should be academically one level higher than the level being taught. Thus only Diploma holders and few certificate holders of ITIs will be eligible for teaching skilled tradesmen. Similarly an engineer with basic degree is adequate to teach diploma students. Specialization will be necessary [illegible] teaching degree students.

There are presently no teaching systems for training engineer teacher. Use of communication skills, modern techniques of teaching like audio-visual aids, rapid reading methods should form part of the teachers training course.

An engineer teacher should have sound practical experience so that his teaching is relevant. Every teacher should have been associated with the practical execution of works. Engineer teachers should also be required to spend some time on refresher training.

Engineer Manager

As indicated earlier, training of Engineer Manager includes a basic Engineering Degree. His training will be more in the form of varied and extensive executive experience.

Specialist to Engineer Teacher, Scientist and Engineer Managers

The non-formal system in this respect will be IITs, industries and universities, through extended facilities. Every major industry has its own R&D programmes and they are ideally suited to undertake R&D work. Indistries are also in a position to finance such pursuits on a large scale. Non-formal channel of education in this context should include quality improvement programmes during special study leaves as well.

Model for Non-formal Education

A model for non-formal system of education on above lines is shown in Fig 3. This model also indicates the nodal points for integration of formal and non-formal systems at different levels.

APPENDIX I

SPECIALIZATION : BRANCHES OF ENGINEERING

1 Public Health

2 Agricultural

3 Refrigeration and Airconditioning

4 Airfields

5 Highways

6 Soils and Foundations

7 Construction and Management

8 Electronics and Control Systems

9 Instrumentation

10 Power

11 Water Supply and Hydraulics

12 Industrial Management

13 Automobiles

14 Project Management

15 Construction and Earthmoving Plants

16 Transportation

17 Workshop Technology

18 Electric Machines

19 Electric Power Systems

20 Chemical

21 Space

22 Computer Science

23 Aeronautics

24 Irrigation and Flood Control

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12 Industrial Management
13 Automobiles
14 Project Management
15 Construction and Earthmoving Plants
16 Transportation
17 Workshop Technology
18 Electric Machines
19 Electric Power Systems
20 Chemical
21 Space
22 Computer Science
23 Aeronautics
24 Irrigation and Flood Control

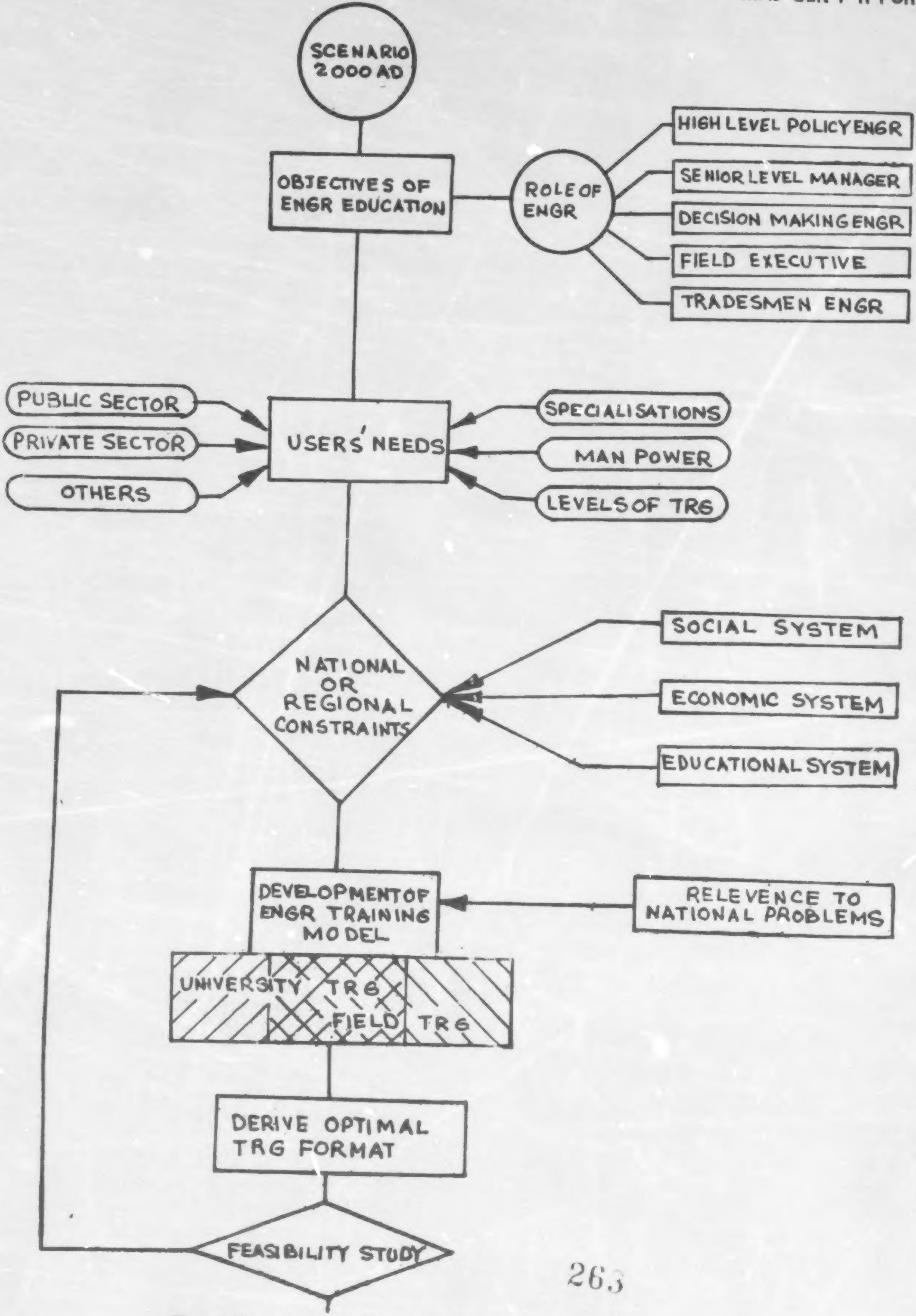
SCENARIO 2000 AD
OBJECTIVES OF ENGR EDUCATION
ROLE OF ENGR
HIGH LEVEL POLICY ENGR
SENIOR LEVEL MANAGER
DECISION MAKING ENGR
FIELD EXECUTIVE
TRADESMEN ENGR
PUBLIC SECTOR
PRIVATE SECTOR
OTHERS
USERS' NEEDS
SPECIALISATIONS
MAN POWER
LEVELS OF TRG
NATIONAL OR REGIONAL CONSTRAINTS
SOCIAL SYSTEM
ECONOMIC SYSTEM
EDUCATIONAL SYSTEM
DEVELOPMENT OF ENGR TRAINING MODEL
RELEVENCE TO NATIONAL PROBLEMS
UNIVERSITY TRG
FIELD TRG
DERIVE OPTIMAL TRG FORMAT
FEASIBILITY STUDY

Fig. 1 Planning in Engineering Education Systems Methodology.

7

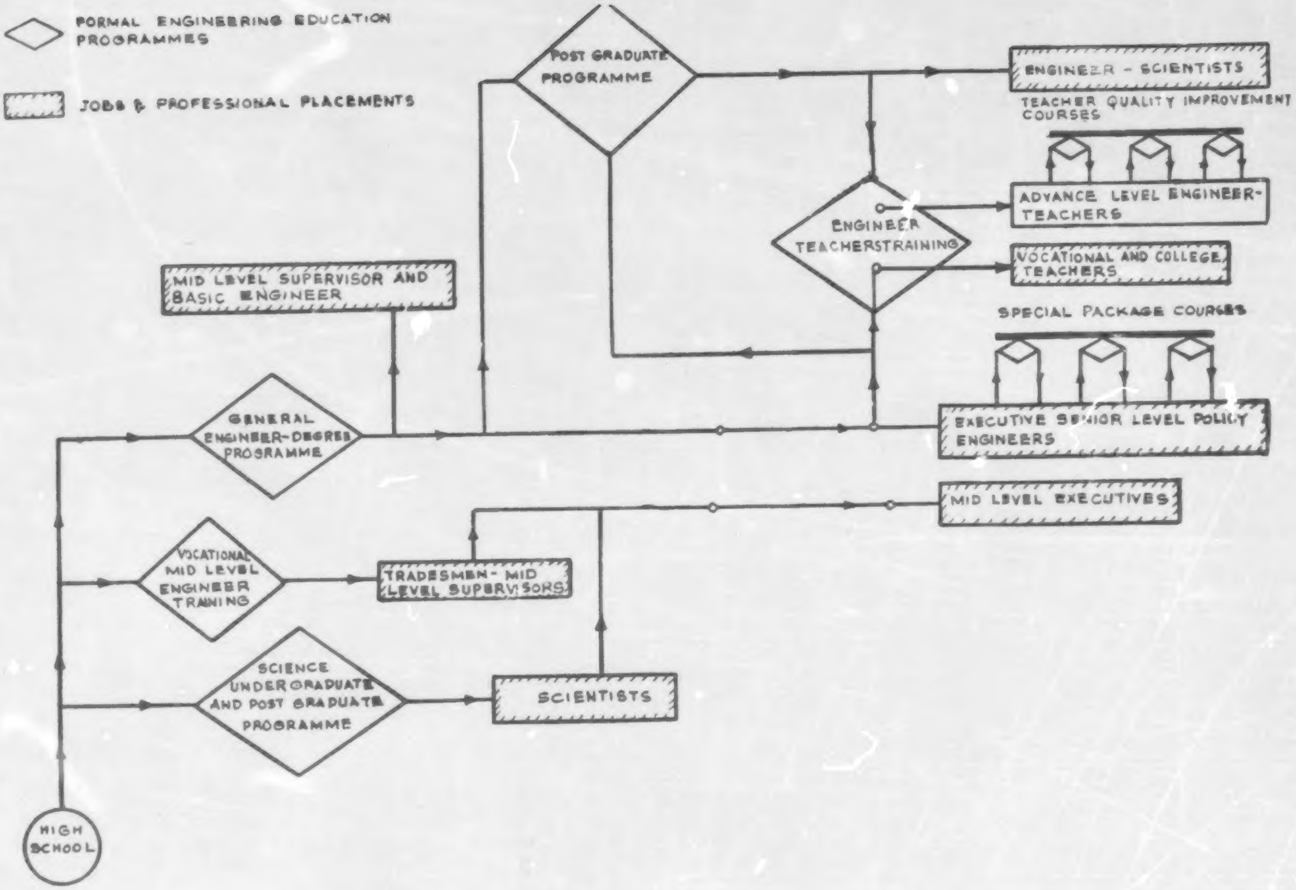
FORMAL ENGINEERING EDUCATION PROGRAMMES
JOBS & PROFESSIONAL PLACEMENTS
POST GRADUATE PROGRAMME
ENGINEER - SCIENTISTS
TEACHER QUALITY IMPROVEMENT COURSES
ADVANCE LEVEL ENGINEER-TEACHERS
ENGINEER TEACHERSTRAINING
VOCATIONAL AND COLLEGE TEACHERS
SPECIAL PACKAGE COURSES
MID LEVEL SUPERVISOR AND BASIC ENGINEER
GENERAL ENGINEER-DEGREE PROGRAMME
EXECUTIVE SENIOR LEVEL POLICY ENGINEERS
MID LEVEL EXECUTIVES
VOCATIONAL MID LEVEL ENGINEER TRAINING
TRADESMEN- MID LEVEL SUPERVISORS
SCIENCE UNDERGRADUATE AND POST GRADUATE PROGRAMME
SCIENTISTS
HIGH SCHOOL

Fig. 2 Proposed Engineering Education Programme.

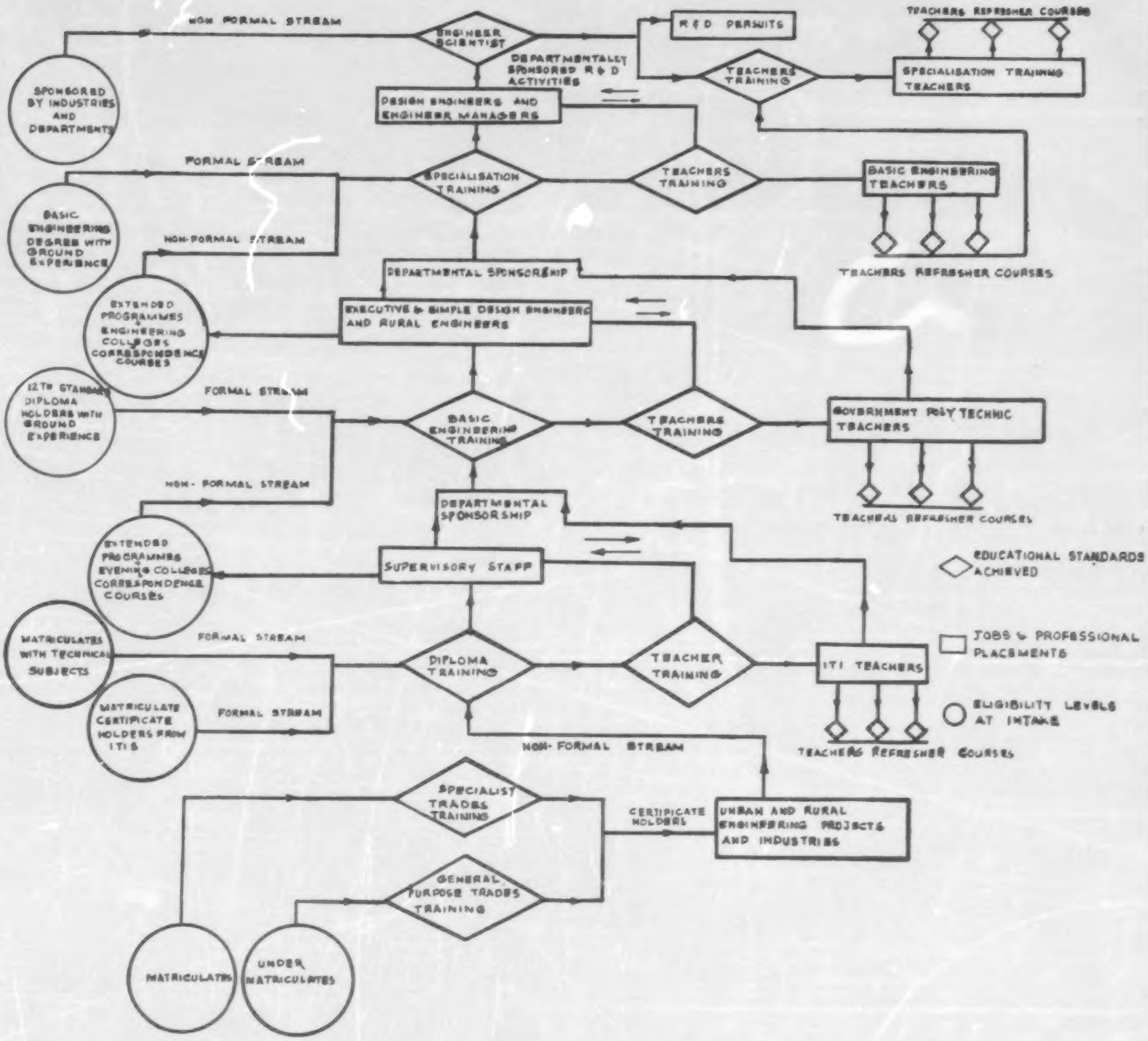
NON FORMAL STREAM
ENGINEER SCIENTIST
R & D PERSUITS
TEACHERS REFRESHER COURSES
SPONSORED BY INDUSTRIES AND DEPARTMENTS
DEPARTMENTALLY SPONSORED R & D ACTIVITIES
TEACHERS TRAINING
SPECIALISATION TRAINING TEACHERS
DESIGN ENGINEERS AND ENGINEER MANAGERS
FORMAL STREAM
SPECIALISATION TRAINING
TEACHERS TRAINING
BASIC ENGINEERING TEACHERS
BASIC ENGINEERING DEGREE WITH GROUND EXPERIENCE
NON-FORMAL STREAM
TEACHERS REFRESHER COURSES
DEPARTMENTAL SPONSORSHIP
EXTENDED PROGRAMMES + ENGINEERING COLLEGES CORRESPONDENCE COURSES
EXECUTIVE & SIMPLE DESIGN ENGINEERS AND RURAL ENGINEERS
12TH STANDARD DIPLOMA HOLDERS WITH GROUND EXPERIENCE
FORMAL STREAM
BASIC ENGINEERING TRAINING
TEACHERS TRAINING
GOVERNMENT POLYTECHNIC TEACHERS
NON- FORMAL STREAM
DEPARTMENTAL SPONSORSHIP
TEACHERS REFRESHER COURSES
EXTENDED PROGRAMMES + EVENING COLLEGES CORRESPONDENCE COURSES
SUPERVISORY STAFF
EDUCATIONAL STANDARDS ACHIEVED
MATRICULATES WITH TECHNICAL SUBJECTS
FORMAL STREAM
DIPLOMA TRAINING
TEACHER TRAINING
ITI TEACHERS
JOBS & PROFESSIONAL PLACEMENTS
MATRICULATE CERTIFICATE HOLDERS FROM ITIS
FORMAL STREAM
ELIGIBILITY LEVELS AT INTAKE
NON- FORMAL STREAM
TEACHERS REFRESHER COURSES
SPECIALIST TRADES TRAINING
CERTIFICATE HOLDERS
URBAN AND RURAL ENGINEERING PROJECTS AND INDUSTRIES
GENERAL PURPOSE TRADES TRAINING
MATRICULATES
UNDER MATRICULATES

Fig. 3 Model for Non-formal and Integrated Engineering Education Programmes.

NONFORMAL APPROACH TO DISSEMINATION OF ENGINEERING KNOWLEDGE

B N Nityanandan*

INTRODUCTION

The progress of a contry depends upon the modernization of the society in all phases of life. A nation's capacity to provide effective channels for technology transfer, technology innovation and technology utilization determines the state of its economy[1]. Most economic historians have concluded that why the Industrial Revolution occurred in Britain and not elsewhere was due to the openness of the British Society. This openness applied not only to social mobility and political and moral liberalism but the way in which different sections and strata of society were permeable to new scientific ideas. To assure rapid modernization of a country, the knowledge of Science and Technology has to be disseminated effectively among all sections of its people. Formal Education Programmes at Universities are now made available to all sections of our society; But it has been realized that there are many hurdles which are to be removed for a satisfactory level of education among the masses and this has led to the introduction of a few nonformal education programmes in arts and science. So far no serious attempt has been made to discuss the need for nonformal education in engineering.

As a professional person in the society an engineer has obligations to meet the demands for the continual improvement of man's environment. He can do this only by working steadily to push back the frontiers of knowledge of the profession. Engineering is a creative profession and it is only by increasing the knowledge levels of all grades of persons participating in that profession that overall development can be assured. Thus there is a need for programmes to update the knowledge of practicing engineers, technicians, skilled and unskilled labourers and even the common man. This stupendous task cannot be performed by relying solely on formal education and training programmes, but by developing nonformal education programmes for dissemination of engineering knowledge.

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NONFORMAL EDUCATION FOR ENGINEERS

Advances in science and engineering knowledge follow a logarithmic pattern in that each discovery or invention opens many additional areas for exploration. A graduate engineer finds that his engineering knowledge becomes obsolete within the first ten years of his career unless he takes care to update himself in the progress of science and development of new technologies. It is worth emphasising that not only in engineering developments but also in scientific discoveries that an engineer shall be uptodate. This is because there is always a time lag, sometimes large and sometimes small, between a discovery and practical applications of the discovery and an engineer who is familiar with recent scientific progress can help his country to forge ahead without waiting to borrow 'developed technologies' from abroad.

Sudden spurts in a country's industrial activity are often due to 'growth industries[2](Industries specializing in new fields such as electronics, new pharmaceutical products, etc. having remarkable growth rates). The growth industries are based on the exploitation of new developments and new knowledge in science and technology. The nature of these growth fields is such that practical on-the-job experience is not a suitable substitute for scientific training.

An engineer is not a standardized product. Different positions require different qualifications and no one will meet all the requirements. The mobility of engineers is essential for rapid industrial growth and in order that an engineer may move to different positions beneficial to himself as well as to the industries, he will have to learn more about new areas of engineering endeavour. It can therefore be seen that in the interests of the industries as well as those of the engineers, it is essential that the practising engineers shall have opportunities to participate in continuing education programmes.

Many continuing education programmes are run in the country in the form of special courses and summer schools. Institutes of higher engineering learning usually offer these courses for short fixed durations, the dates and timing being chosen by considerations such as the vacation period for the institute, availability of accommodation in their guest houses,etc . An industry which may want to sponsor its engineers for these courses may never be able to do so because the period of these courses may coincide with the period of the industry's peak activity. Further the organization of the courses is usually on a general purpose basis, that an engineer participating in it may not derive the full benefit of all the days he spends at the campus. Thus these courses tend to be formal because of lack of flexibility in the time, duration and methods of organization of the courses.

In addition to the existing type of continuing education programmes, nonformal programmes must be offered in order that the practising engineer may learn at his leisure and convenience. The institutes of higher engineering education may devise flexible programmes in which courses will consist of printed lessons or monograms for self-study. Technical articles and published papers may be collected in specific areas the collections giving full information about particulars developments. This must be accompanied by discussion at the learner's convenience. The learner shall have freedom to discuss about his topic of interest not during a formal orientation course or tutorial sessions but he shall have access to the in-campus-expert throughout the year. The laboratories in these institutes may also be thrown open to these 'nonformal students' giving them freedom to do their own experiments and develop their own circuits and designs and undertake projects of immediate appeal to them.

This will foster close ties between practising engineers and the campus brains and will pave the way for increased teamwork[3]. Developments in the areas of nuclear power, computers, missiles and operations research have all been due to teamwork and all indications point more and more to the use of teamwork as the sumtotal of scientific and engineering knowledge becomes greater. Flexible nonformal contacts will ensure continual interaction between the educators and practitioners which is mutually beneficial.

A certain percentage of the staff of these institutes may be exclusively assigned for this work or or every professor may be given a certain credit for his nonformal guidance work. The increased expenditure will have to be met atleast partly by the industries or companies sponsoring the engineers for nonformal work in the engineering college or institute of technology.

Another direction in which nonformal courses can be channelled is running off-campus courses. The Bell Telephone Laboratories which has one of the largest research laboratories in the world and would appear to be self sufficient has an arrangement with New York University to provide programmes of instruction on the Bell Telephone premises. Similar courses offered by the

University Staff at the premises of Industries and research laboratories will attract more industrial participation and will be more achievement-oriented.

NONFORMAL EDUCATION FOR TECHNICIANS AND SUBPROFESSIONAL WORKERS

It is worth mentioning that all statistics published by the Government of the USSR counts techncians and subprofessional workers as engineers recognizing their contribution to the cause of technological development.

The problem of training technicians and subprofessional workers is important from the point of view of major industries as well as that of small industries[4]. In any society, for a considerable part of the transition period from premodern to modern economy, earlier forms of small industry predominate. An important aspect of the problems facing development planners is how to guide the transition from traditional to modern small industries. About 40% of the net output of registered Indian factories is produced by small factories which rarely employ graduate engineers but employ only technicians and akilled workers.

The dispersed factory system has considerable importance in newly industrializing countries and its special aspects exist in highly industrialized countries also[4]. Under this system the workers complete their tasks in their homes or small work places and will be rendered jobless unless they are prepared to cope with advanced techniques and changing trends in production. Training the labourers in new skills will also aid 'labour mobility' which is essential for dynamism in the small industries.

One of the major hurdles experienced by most industries in introducing new technology into their production is the technological inertia of their staff. People who don't feel competent to handle the new situation offer resistance in many disguises and this technological inertia has been found to retard the progress of the companies. Continuing education programmes for technicians will enable them to shed this inertia by infusing confidence in them to handle new equipment, instruments and devices. Consequently it will also help to minimize retrenchment or reallocation problems arising out of modernization of industries. The dearth of continuing education programmes for technicians and subprofessionals in India is alarming and this problem needs immediate attention. The continuing education programmes for this group may also be flexible to the degree possible and shall aim at updating their technical and scientific competence and train them in the use, maintenance and repair of new instruments and equipment.

KNOWLEDGE FOR COMMON MAN

In order that the benefits of Technology reach the common man and the society as a whole becomes more technologized, engineering knowledge has to be imparted to all people who have the aptitude irrespective of their educational qualifications. A common **man**'s interest in acquiring some engineering knowledge will be generally because of the requirements of his particular profession or trade and he is more likely to be interested in updating his knowledge and improve his skills in a narrow limited area than to acquire general proficiency in engineering. If he is provided, by suitable nonformal education facilities to improve himself, technology is sure to take firm roots in the society. Nonformal education for this category must consist of access to laboratories and workshops in the polytechnics, industrial training institutes and other trade shcools. Periodical courses may also be offered completely free from high sounding theory and mathematical analysis. The courses must adopt a qualitative, logical commonsense approach and shall contain more practical work.

For engineering knowledge to spread more widely among the people, lessons may be prepared and instructions given in the regional languages. Also projects for writing books containing diverse engineering knowledge suitable for laymen may be undertaken. The expenditure incurred in educating the masses will necessarily have to be borne by the state. The expenditure involved may prompt the state administration to be hesistant, but the long term benefits of imparting scientific and technical knowledge to the common man should prevail upon their reservations.

CONCLUSION

Only by continually increasing the knowledge levels of all grades of persons involved in engineering activities will it be possible to ensure rapid growth of our industries and economy. As in other areas, nonformal education is essential in disseminating engineering knowledge also. The nonformal approach may be along the following lines :

1 Flexible continuing education programmes may be devised providing for study and discussion at the learner's convenience. The 'nonformal engineering students' sponsored by their research laboratory or industry may be allowed full freedom to utilize the facilities available in the institutes of higher learning to learn about the developments in areas of their interests and take up project works with immediate appeal to them.

2 Off-campus courses may be run at the premises of an industry or research laboratory to attract larger participation and congenial environment.

3 To help the middle level and sub professional workers to shed their technological-inertia, flexible continuing education programmes must be planned to aid their continued technical competence and improve their skills. This will be of immense use for peoples in small industries and those involved in the dispersed factory system. This will also increase labour mobility essential for all round growth and help to minimize retrenchment and reallocation problems in modernisation schemes.

4 To technologize the society as a whole, scientific and engineering knowledge must be imparted to all people who have the aptitude irrespective of their educational qualifications. Training programmes to appreciate and acquire acquire a few engineering skills may be organized.

5 Lessons may be prepared and instructions given in the regional languages, so that language is not a barrier for the common man in satisfying his engineering appetite. Projects for writing books containing diverse engineering and Scientific Knowledge suitable for laymen may be undertaken,

Only by devising means to enable the engineers and others involved in their industries or projects to become familiar with and master new technologies and educate the common man with aptitude that it will be possible to strengthen the base of technology in the country.

REFERENCES

1 William Gruber and Donald Marquis. 'Factors in the transfer of Technology', M I T Press, 1969 (Book).

2 John R Whinney. The world of Engineering, McGraw Hill Book Co., 1965 (book).

3 B N Nityanandan. 'Role of Teachers and Alumni in Curriculam Development' - Regional Seminar on Technical Education, Government College of Technology, Coimbatore, March 1972.

4 E Staley and R Morse. 'Modern Small industry for developing nations', McGraw Hill Book Company, 1965(Book).

FEEDING INDIA IN 2000 AD

T Ramasarma*

India is producing about 9% of total food grains of 1200 million tons in the world with 15% of its population. It is to the credit of agriculturists and scientists in the country that food production had increased even beyond expectation during the decade of seventies, and the predicted famine in 1974 never came. We have known the terrible results of famine in parts of the world and India earlier and it will be unthinkable in this age of science to let famine recur anywhere. Providing enough food shall be uppermost in any planning for development1.

We depend on food grains as the primary source of food energy derived in the following way: food grains (52%), tubers (10%), vegetables and fruits (10%), fats and oils (9%), livestock (11%), sugar (6%) and fish (2%). An average diet2 with the calories supplied by each component is given in Table 1. There are variations depending on the resources of the region and economics of the population as well as the total energy needs of an individual. Ironically the manual labourer requiring much larger number of calories has the lowest purchase potential.

TABLE 1 AVERAGE DIET*

Component	Grams/day/person	Calories/day/person
Cereals and tubers	370	1450
Sugar	50	200
Pulses	40	140
Vegetables	90	20
Fruits	70	40
Meal/eggs/fish	40	60
Milk/dairy products	120	80
Fats/oils	20	180
Total :	700	2170

*Adapted from FAO Report No 33

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Rice and wheat, the staple foods in India form nearly two-thirds of the total grain production. Nearly 40% of world's food energy is derived from wheat and rice and they have a more dominant hold in Indian food habits. The grains produced in the developing countries, and in India, would suffice to give the minimum of 2000 calories/day/person on proper protection from losses and just distribution[3] (Table 2).

TABLE 2 AVAILABILITY OF FOOD*

	World	Developing Countries	India
Population, millions	4013	2956	620
Cereals, millions of tons	1233	552	124
Available food			
-kg/year/person	307	187	200
-Grams/day/person	725	400	547
-Calories/day/person	4205	2562	2200

*Data from UN Statistical year-book

The data gives the impression that the available food materials can sustain minimum requirements. But the production is mainly concentrated in the continents of North America and Australia and there alone the food surpluses exist.

The food grains are fed to livestock in the affluent countries to obtain the preferred form of animal food. Placing palatability above efficiency, 5 to 7 times more calories in grains are spent for each calorie of animal food. Keeping to differing food styles, each person in the developed countries consumes the primary food grains that could feed four persons in the developing world. Livestock is obviously not efficient converter of food energy and its continued production involves competition between animal and human requirements for grains. The consumption of food of animal origin increases with increase in living standards. This is happening at the level of countries and also sections of population in the country. The price of energy inputs for satiating such pleasure of consuming diets of animal origin is too large to pay. It is not true that vegetarian diets are incomplete. It is equally not true that animal diet is necessary for better health. It is interesting to recall that Roman armies marched and carried out tremendous tasks and ate primarily wheat gruel.

Given the present food situation, India cannot increase dependence on animal diets and should support only those that do not consume primary food grains. Fortunately India, has an established tradition for vegetarianism. Gandhiji even considered that simple foods help in developing a personality 'allaying animal passion'. There are a number of great historical personalities who practised vegetarianism such as Pythogoras, Buddha, Leonordo da Vinci and Benjamin Franklin[4].

The present practices of food production in North America are energy intensive and use little labour force. These are unsuited for India which has 70% of its population dependent on agriculture for livelihood. Large scale farming requires large machinery using fossil fuels. The production per unit labour force is higher in these countries. But small size farms with inputs of greater labour and less of energy are more economical and output from the land is 4-10 times greater[5]. Considering the number of calories spent in fuel costs alone the production of food grains would be prohibitive with these modern technological methods of farming. In effect the carbon in the atmosphere and fossil fuels is being converted into human biomass. Mechanization, massive chemical fertilizers and pesticides, storage, processing, transportation have all added up to the energy costs. The energy output/input ratios for the food crops sorghum, sugar cane, corn wheat and soyabean are more than one[6]. When these are fed to animals to obtain meat the ratio falls to less than 0.02. With increasing affluence there is a shift in food styles imposing greater demands on overall requirements and production. It should be remembered that it is the 'over commitment planning of enrichment of the Soviet diet at a greater rate than can be sustained by domestic production' that led to import of food grains by USSR[7].

There is a need for a social control of food styles in our country. Those eating sorghum are asking for rice and the rice-eaters are longing for meat — a decreasing order of efficiency with increasing strain on the available food. The demands will have multiplier effect with increasing population. This view of control infringes on freedom and aspirations and will lead to controversy. The inevitability will be understood by the following discussion.

By 2000 AD the population in India will be between 900-1000 millions. By whatever measures this large number of mouths will have to be fed. To obtain the minimum needed calories of 2500 per day per person, nearly 200 million tons of food grains must be produced - a 60% increase of the present production at the least within two decades. The present growth rate for food is just able to keep ahead of that of population (Fig 1). Even presently, we are maintaining partly a 'starvation culture' with one out ∠of three subsisting on less than minimum. The 20 million tons buffer stock of food we are boasting of will not be there if these people have means to buy and eat two meals a day. With increasing economic prosperity that is bound to happen. More food will be needed and the food curve will have to slope upwards as we face the new century. To give a balanced diet to all Indians by 2000 AD projected needs are given in Table 3. They add up the staggering figure of about 600 million tons of food materials in a year with the constraints of population and food styles remaining in predictable limits.

TABLE 3 PROJECTED NEEDS OF FOOD MATERIALS IN INDIA IN 2000 AD

Component	Millions of tons	
	Minimum	20% overrated
Cereals	160	192
Pulses	40	48
Vegetables	100	120
Oils	25	30
Fruits	35	42
Milk/dairy products	100	120
Sugar	40	48
Meal/eggs/fish	30	36
Total	530	636

Some pragmatic approaches have to be emphasized, both positive and negative, which hopefully are incontrovertible in the context of feeding India in 2000 AD.

1 Food needs have to be met by producing them within the country.

2 The dwindling surpluses of North America will not be able to come to the aid.

3 Large labour force in the country and small farms have to be combined for maximizing food production.

4 Large-scale mechanized farming methods are energy intensive and unsuitable.

5 Newer scientific fats such as synthetic food and protein from petroleum are illusory and non-solutions.

6 Dependence on natural food sources and food grains is unavoidable.

7 Promote food styles based on available combination of food materials, introducing changes where necessary.

8 There should be no misconception that traditional methods of farming are adequate.

9 Without massive backing from technology, chances of achieving the targets are remote.

These then should lead to the strategies. In this endeavour what are the roles of scientist and the engineer ? Are they prepared to assume their roles ?

To cope with the massive food needs, the tasks are to put more land under cultivation, increase the available water, produce fertilizer at low cost and develop strains of food-bearing plants for higher yields. The following are some of the technological needs:

1 Obtain crop varieties that can stand the climate, the soil and pests

2 management of fresh water, considered the ultimate limiting factor

3 manufacture of fertilizers and pesticides

4 improve methods of storage, preservation and processing of grains and food products in small scale

5 design of farm machinery and tools for operation in small farms to supplement and not to supplant the large labour force.

6 providing the network of transport, communication and marketing for proper distribution on regional basis.

There are a variety of direct and indirect ways that the engineering principles can be used in this massive effort. Foremost of all is making water available. Rains in India are erratic and uneven. Agricultural capability can be increased by increased use of the water in the Indian river system otherwise wasted. We only use a third of the water and it can be doubled[9]. It may look too obvious how engineers can play their role, considering the widespread nature of the farming land, wide range of water sources and the peculiar need of the small farming system. Can we think of all the possible engineering solutions for such situations ?

Often air is taken for granted as an unlimited and untaxed source. All productivity of organic food depends on photosynthesis by the wonder chemical, chlorophyll, in the green plants which fixes atmospheric carbon dioxide using the bountiful solar energy. The supply of carbon dioxide in the air is 0.03% and is mopped up in millions of tons by plants every day the sun shines. The efficiency of this process can be as high as 5-8% but we hardly realize an efficiency of 1-2%. All food-bearing plants, handed down to us by our ancestors (who are not 'scientists') are of the less-efficient C_3-variety which lose part of the fixed carbon back to atmosphere by a functionally mysterious process called 'photorespiration'. Wheat and rice belong to this category. Another type of plants called C_4-variety developed mechanism to retain carbon to a larger extent and give higher yields. Corn, sorghum and sugar cane belong to this category but these are not the foundation crops for our food style. One definite way to improve the yields of any of these is to increase the concentration of carbon dioxide in the air. Proportionate increase in the productivities are observed[10]. Increased burning of fossils fuels had resulted in continuous increase in carbon dioxide which is expected to be 30-40% higher by 2000 AD[11]. Can a technological quirk make localized increase in available carbon dioxide in the farm by burning or digestion of otherwise useless organic matter ?

It is felt that there is not much more good land, certainly not 60% more, to draw into cultivation. Soil management of poor quality land with added manures may offer some peculiar challenges. Fertilizer inputs are already heavy[12]. The increased yields are directly correlated with the fertilizer inputs but we may soon reach the point of diminishing returns. Firstly because this depends on the soils, some requiring much more for the same yields as the good ones. Secondly the inorganic fertilizers are obtained from large petrobased industry and the costs, for a variety of reasons, are soaring. Can the technology devise medium scale less-expensive fertilizer plants distributed all over the country ?

It is now recognized that small scale farms utilizing large labour force is the option for our country. It is likely that a 2-fold increase in implements tools and machinery is needed for a variety of jobs connected with farms. Even though these are not large scale mechanized units, quantitatively even larger tonnage of steel and efforts have to be put in. A variety of these have to be developed to aid the farmer to relieve the burden of this labour, the marketing process in storage and transport and the food technologist to process the food materials. Some of these do not even exist now. Can the engineer use the ingenuity in inventing and manufacturing these ?

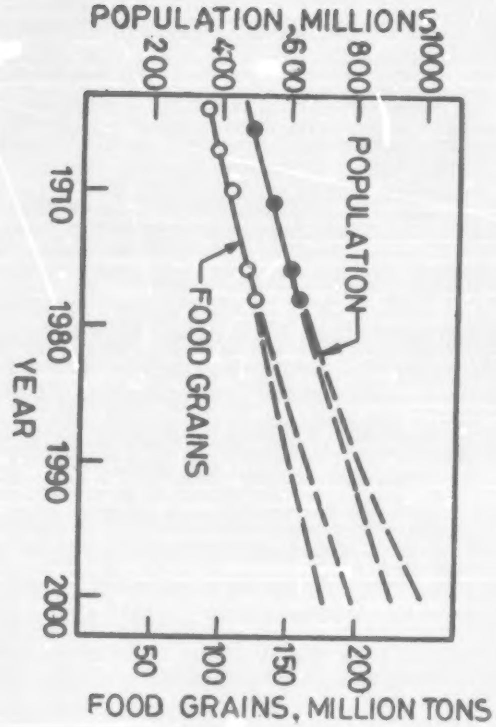

Fig. 1 : Projections 2000 AD : Population and Food.

In a variety of ways the technologists have to assist in various stages of food production and processing. The farmer is the visible link between the land and the food production. But it is to be realized that his success will depend on the scientific and technological support that can not be underestimated. In fact the engineer gives the prop for the hand that holds the food.

REFERENCES

1 Charan Singh. India's Economic Policy - The Gandhian Blueprint. Publ Vikas, New Delhi, 1978, p 92.

2 FAO Report No 33, Inter-African Conference on Food and Nutrition.

3 S Ramakrishna, T Ramasarma and K I Vasu. National Paper of a Typical Developing Country-ASHA, Publ ASHA, Indian Institute of Science, Bangalore, 1978.

4 E Garfield. The Vegetarian Alternative, *Current contents*, *11*, 5 (1977).

5 S Wortman and R Cummings Jr. To Feed this World - the Challenge and the Strategy, The Johns Hopkins Univ Press, Baltimore, 1978.

6 G H Heichel. *American Scientist*, *64*, 64 (1976).

7 J R Millar. The Prospects for Soviet Agriculture, in 'Problems of Communism', 24, 1 (1977).

8 C Gopalan. Food Needs in Qualitative Farms, in Science and India's Food Problem. Publ Indian Council of Agricultural Research, New Delhi, 1971, p 27.

9 Water Management-Some Useful Information, *Yojana*, *22*, 7 (1978).

10 T Ramasarma. Inter-relationship of Food, Nation and Environment, in 'Science in the Service of Basic Human Needs. Publ: Andhara Pradesh Akademi of Sciences, Hyderabad, 1976, p 79.

11 J Williams. Global Energy Strategies: The Implication of CO_2 *Futures*, *10*, 293 (1978).

12 L R Brown. World Food Prospect, *Long Range Planning*, *10*, 26 (1977).

NEED FOR A NEW DISCIPLINE - 'ARCHITECTURAL ENGINEERING'

Sheo Dan Mal

For an integrated and balanced development of a society, both science and art should be encouraged to play their due roles. In fact, their roles themselves should be so integrated that one may not have any separate identity in the absence of the other. This applies equally well to the creation of physical infra-structure and built-up environment. There has to be optimum synthesis of both science and art that is, thinking and feeling, not only in the spheres of education and culture but also in each physical creation, whether it be a bridge, a road, a building or even an object d'art. In case of utilitarian structure such as a bridge, admittedly applied science, viz, engineering, is bound to play a dominant role, though feeling aspect, that is, aesthetics, as visual satisfaction through harmony with nature is much involved, cannot be neglected. As against this, though an object d'art is primarily created for aesthetic satisfaction and to evoke intense feelings, its creation itself is made possible through engineering principles, may their role be relatively less in comparison. In between these two extremes of utilitarian and aesthetic objects, lie a vast field of creation, major share of which belongs to buildings, in which engineering and aesthetics should play almost equally important roles.

Buildings, both in urban and rural areas, whether meant for housing, commerce, industry, education, administration, health, culture or even storage, besides being important aspect of developmental activity, occupy an important place in visual and physical environment. And as, it is the environment that moulds the character and behaviour of man, and through him of the society as a whole, the importance of the role of buildings in building of a nation cannot be underestimated.

Building industry is the second largest industry in the country ranked next to agriculture, both from financial commitments as well as employment potential points of view. It has to play even a larger and bigger role in future. Apart from creation of new buildings and clearance of huge backlog of housing units, due to ever present obsolescence and ever rising standards, renovation and replacement of buildings, are and would always remain as continuing activities.

Inspite of the importance of buildings, both as means of the development of national economy and as tools of general social development, not much attention has been paid to create good ones. True, some ivory tower institutions like Central Building Research Institute or National Building Organization have been established and Indian Standard Institution has formulated some useful codes, their efforts have not proved of much use, in as much as their recommendations have not percolated down to the field level. In fact where are the personnel who can implement such recommendations ? Also there is no hope that the structure of organizations that at present handle the building industry, would be ever able to create suitable conditions for their implementation. Supposing that some miracle would happen, and that we shall be fully equipped to utilize all the information and knowledge so gathered, what about the other aspect and a very important one at that the 'aesthetic' aspect? We have never cared to even look at it.

Many grievious mistakes have been committed, may be because of variety of reasons, historical, social and political and perhaps because we were in great hurry to build. But should we, even after more than three decades of independence, allow ourselves to go on committing such mistakes ? In view of the huge financialcommitments and the high social stakes involved, haphazard development in this field, without involvement of thinking and feeling, would not only be wasteful but even anti-social. It is high time therefore to think of training suitable personnel, who can man this industry with competence and confidence. As both technical as well aesthetic aspects shall have to be necessarily involved, the training programme could appropriately be named Architectural Engineering.

(1) As at present, majority of buildings in our country are being planned and constructed by unqualified supervisors or more often by ignorant owners themselves. This certainly needs corrective orientation. Leaving this aside (hoping that situation would imporve in due course of time) whatever buildings are being constructed by established organizations and enlightened individuals, their planning and execution are being handled by either civil engineers or architects. Even a cursory look at the

syllabi of both these disciplines, viz, civil engineering as well as architecture, specially in the context of ever increasing complexities of the building industry, would make it amply clear that neither the person trained in one nor that trained in the other is equipped well to face the problems posed by the industry.

In this age of specialization, one may argue and maintain that scope of each of these two disciplines being vast, they have to remain separate and their identities cannot be merged. It may also be argued that there has to be further specialization in each of the above disciplines in the wake of explosion of knowledge all over. In fact such diversification and specialization is already taking place at post-graduate level. Nobody questions the validity of this approach. It is, however, evident that as far as building activity is concerned, a new type of engineering is needed who through an integrated approach, evolved by virtue of his training, can create scientifically sound and aesthetically satisfying built-up environment.

The protagonists of specialization, recommend team work to achieve integrated planning and execution of building projects, not only between these two disciplines, but rightly so, amongst several others, all specialists in their own spheres. Admittedly such team work has resulted in successful execution of some building projects and does deserve all encouragement. While conceding this, we are forgetting two important aspects. One, that there has to be a co-ordinator to coordinate and integrate the roles of all these specialists of the team, may that be an engineer or an architect who acquires this skill of coordination not by his training, but through his experience. He must have this professional skill, however. This proves that the role of a suitably trained architectural engineer is an important one in coordination and integration of team work.

The second aspect that we are missing as far as validity and application of team work is concerned, is that such team work is neither desirable nor practicable under all situations and at all levels. Maybe, it is possible and even necessary in case of large and prestigious projects. But in our country, major building activity consists of small buildings and projects, where such team work is neither possible nor called for. As at present, quality of such buildings both in respect of planning as well as execution, is going down simply by default, as neither the engineer nor the architect is well equipped to deliver the goods. The situation therefore obviously demands the emergence of a new professional, an architectural engineer, who can handle such assignments independently.

(2) With the advancement of science and technology and with the rising aspirations and needs of the society, the planning and construction of buildings is becoming more and more complex. It is no more as simple as erecting walls and putting roof over, nor the recipes contained in building construction text books are enough. Instead, now it has to draw upon multiplicity of highly specialized knowledge. There has been a revolution in construction techniques, different ones for different situations. The structural engineering has proliferated in all directions, involving new materials and new processes. The concrete technolgy demands special attention in its own right. The general dread of pollution and greater awareness of clearner surroundings have led to more involvement of fast developing environmental engineering in buildings. Timber technology, alongwith newer and newer products made possible through it, is finding greater and wider application in buildings. All these subjects admittedly are being taught in civil engineering but the treatment of them is so elementary, atleast as far as building construction is concerned, that a graduate engineer finds himself at a loss when confronted with on-site problems. Worse is the situation with architectural course, where only passing references are made of these subjects. When confronted with this problem of the industry, the educationists in civil engineering contend that as their field is vast, they can only impart basic theories and principles and can ill-afford to give detailed training in techniques related to buildings only. With self justification (though forgetting that engineers are supposed to handle building projects) they point out that building construction is an important part of architectural course and as such the subject has to be dealt with in all details there. On the other hand architectural training and the profession as a whole, is completely absorbed and occupied with aesthetics, and abhors going into details of techniques thinking and arguing all the while, that it is the duty of engineers to deal with them. The unfortunate consequences of this controversy are all around us to see.

Besides the above so called common subjects supposed to be taught in both the courses, there are several other subjects and disciplines, which contribute a lot in making a building functionally successful and about which neither a civil engineer nor an architect is fully conversant specially as regards their application in buildings, Mechanical engineering, electrical engineering and even electronics have come to acquire special place in modern buildings, either as built-in engineering inputs or as necessary adjuncts to construction processes.

And then there are subjects like acoustical engineering, illumination engineering, air conditioning, ventilation, insulation, paint technology and hordes of others, which are recognized only by name, and few if any are aware of their theories and techniques.

Knowledge of the theories and application techniques of all the above subjects would form essential part of the architectural engineering course. Special emphasis however shall have to be laid on integration and devetailing of all these aspects in building projects in such a way that the end result is perfectly harmonious and wholesome one.

(3) Ever increasing rate of urbanization and tempo of development, demand greater efficiency, enhanced speed of construction and savings through reduction in costs of labour and materials. Use of industry-produced components, application of prefabrication techniques and mechanization of construction processes, have to be thought of well in advance and provided for at the initial stages of planning. A large number of items in inventory, perhaps largest amongst all construction activities, is to be efficiently handled. Similarly, a very large number of specialised trades and skills are to be dealt with during course of construction. Thorough knowledge of properties of all the materials, and awareness about the techniques of various trades and skills are necessary for optimum utilization, integration and coordination. Knowledge of labour laws, awareness about safety and welfare measures and ability to manage finances are and should be necessary qualifications of an architectural engineer. In short, construction management should form an essential aspect of his training.

Though largest amongst all industries except agriculture, building industry is most disorganized one. Lack of continuity, casual nature of employment, absence of any industry training programmes and various other related factors, hamper the proper organization. The advent of an architectural engineer suitably trained in construction management would certainly prove to be a relevant factor in bringing about better organization of the industry.

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(4) An important aspect concerning planning, designing and execution of building projects, as already pointed out is "Aesthetics". Without this, a building would be a mere ill fitting structure, a hollow shell, a body without a soul. As such "architecture" shall have to be an important content of training programme in Architectural Engineering.

Broadly speaking, aesthetics could be integrated in a building at three levels or stages, namely, (a) at conceptual planning and designing stage, (b) at planning, designing and integration of services stage and (c) during the execution, by controlling the quality of construction and finishes. While aesthetics at conceptual stage of planning and designing could be, and in case of important projects, should be the rightful responsibility of an architect, the aesthetics involved at stages (b) and (c) should be handled by an architectural engineer, who by virtue of his training in engineering inputs and architecture, would be able to achieve proper integration of technologies and aesthetics.

It has been unfortunate experience of all of us that conceptual architectural designs alone can never produce good buildings. The aesthetic integration of all engineering services, attention to details and the quality of construction and construction and finishes, go a long way in producing good architecture. It is not an aspersion on the quality and importance of conceptual design, but the fact remains, that many such good designs have been spoilt simply because there were no persons on the project, who could take care of aesthetics of integration and execution.

(5) Some may object to the hybrid nature of this course, which may neither produce full fledged architects, nor expert engineers nor competent management consultants. But the nature of building industry require such personnel. They are not supposed to replace any of the above experts, but would in fact by being co-ordinators, would increase the importance and relevance of all these professions. The basic idea is to achieve synthesis so that building industry may be able to play its designated role in the society. The role of an architectural engineer vis-a-vis those of experts in various branches of engineering and architecture could well be compared with that of a general practitioner vis-a-vis those of various specialists in the medical field.

The only difference is that while every medical student is equipped for general practice, no such integrated course has been so far designed to produce an architectural engineer.

(6) The emergence of an architectural engineer on the scene of building industry would not only result in good buildings bringing about better environments and beneficial social developments, but would have other important rammifications in the field of general development too. It is well known that almost all major industries, directly or indirectly depend upon building construction activity. Lack of emphasis on the quality and that of appreciation of the same, had led to general deterioration not only in the quality of various products that go into buildings, but also in skills and craftsmanships. This trend has to be reversed, and would certainly be reversed once architectural engineering finds its due place. Perhaps then, it would be possible to replace exasperating stagnation and apathy with invigorating innovation and invention. In fact, in due course of time, a sort of grass-root industrial revolution would be brought about through new and improved products and through better craftsmanship and workmanship.

(7) In the west, integrated approach towards life and living has already achieved a high degree of synthesis of art and science. Wide choices of subjects available in institutions and universities there, have helped in this process of synthesis. In the fields of engineering and architecture, efforts of stalwarts like Pier Luigi Nervi, Eduardo Torroja, Mies Van der Rohe, Frei Otto, Felix Candela, Backminster Fuller, Freyssinet and several others have strongly advocated and practised this concept of integration of engineering and architecture, and the impact of their works has been wide-spread. Even with so much of integration achieved, specific courses in architectural engineering are available in several universities. That speaks of their awareness about its importance.

As the conditions in our country are far from being conducive to the development of integrated approach, and as the need is so urgent and so great, it is far more necessary to introduce this discipline of architectural engineering in our training programmes. The crying need of the building industry demands it and the fulfilment of objectives of economic and social developments make it indispensable.

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TECHNICAL EDUCATION

Dr V K R V Rao

The qualitative deterioration of technical education is the result of a rate of quantitative expansion that is not sustained by the rate of growth in the inputs necessary for the maintenance of quality. Technology is making rapid advances and industrial processes and techniques for design, construction and production are fast changing. The time has come for us when in the interest of improving our technical education system, we must address ourselves with a sense of urgency to the problems of curriculum development for degree and diploma courses, to the preparation of instructional materials, including text books, and to the development of laboratory experience. As a beginning we have to consolidate and place all our engineering institutions and polytechnics on a sound footing in terms of staff, equipment and accommodation, instead of multiplying institutions and achieving only statistical satisfaction in increasing admission capacity.

The first implication of a revolution in the quality of education is the improvement of the teacher. The phenomenal expansion of technical education has not seen an equal rise in the number of well-qualified teachers. Even as late as 1969 there was a shortage of staff in engineering colleges (16.4%) and in polytechnics (about 15%). The situation has been sought to be remedied by instituting masters courses in engineering, in providing stipends for researchers to undergo courses for improving their teaching qualifications, and by improving salaries and other conditions of work. Summer institutes for teachers have also been instituted - but though these have done substantial work they cannot meet all the demands of faculty development. A carefully planned scheme of participation in field work for servicing teachers at selected industrial organizations has also to be organized.

The Central Government in 1950-60 also initiated a programme of teacher-training for engineering colleges by recruiting brilliant graduates and training them over a three-year period at selected centres. This training included preparation for the masters degree, practical training in industry and other organizations, and inservice training as teachers under the guidance of senior staff. Many first class teachers have been trained and the problem of staff shortage of teachers has been minimize to some extent. A like scheme for training polytechnic teachers at Madras , Bhopal, Chandigarh and Calcutta has also been started. Faculty training is, however, a continuous process that should provide for a wide range of opportunities for securing teachers to improve their knowledge and professional competence on a regular basis and at our present stage of development, emphasis should shift from pre-service to in-service training.

Summer institutes alone will not meet all the demands of faculty development. For instance, a serving teacher needs to know how to organize and relate laboratory and practical work to theory. There is need to develop an innovative and creative approach to teaching. There is the further problem of faculty obsolescence which is assuming serious proportions even in advanced countries. Institutes of technology and selected engineering colleges and polytechnics must organize a wide range of in-service training programmes for serving teachers.

This brings us to the curriculum in individual subject fields for degree and diploma courses. The whole process of technical education improvement from the point of view of both learning and teaching is mainly dependent upon the continuous revival and updating of the curriculum. It is the absence of sufficient effort in this direction that is responsible for the various defects in our technical education system at all stages. Mostly teachers and students are solely dependent upon text books and other instructional materials produced abroad. We must address ourselves, therefore, to the preparation of indegenous curricula and teaching materials bearing on our industrial requirements.

There is a scheme for setting up curriculum development centres and adequate arrangements must be made for wide dissemination of the materials produced.

Serving teachers must also be equipped with industrial experience. Teachers, however good, become out of date without practical experience in industry from time to time. A scheme should be planned for teachers to do field work in selected industrial organizations either during vacations or for longer periods of a year or two depending upon the needs of each industry.

To plan for the future, we may take a look at the education given in our polytechnics and the Indian Institutes of Technology set up as centres of excellence in different parts of the country.

The criticism of polytechnical education is that it is not sufficiently practical in its orientation. We know how important is middle level manpower for the wide range of professional duties it is called upon to perform. The technician is concerned with the application of known knowledge to field operations in production and construction, testing and development, installing and running engineering plants, drafting and designing products, estimating costs, selling and advising customers on the use of engineering and scientific equipment. The technician who acts as a liaison between the engineer and skilled craftsman to interpret the foreman's plans and designs, to determine the type of production and construction techniques to be adopted and to choose the tools and machines best suited to specific jobs. The purpose of the technical institute curriculum is not only to impart a sound, broadbased theoretical knowledge of a chosen engineering field but also to mould and develop the attitudes and aptitudes of the student towards optimum proficiency and productive capacity for immediate employment. The education given in a polytechnic must be cross-fertilized with practical experience in industry so as to expose the technician trainee to actual working methods, techniques and skills relevant to his field of speciality in drafting, design and development of products and engineering plants, in installing and operating equipment in construction, in estimating costs etc. He must also be made to observe and understand how the engineering principles and their applications are translated into practical operations and processes in the design office, on the shop floor and in the field, acquiring sufficient occupational competence to be able to perform the same professional functions independently when employed on the job. To coordinate theory with practice, to relate teaching to industrial work and to elaborate the complementary functions of technical institutes and industry - all this is the heart of the technician training. Our concern must be to develop a system of polytechnic education that articulates the joint and co-operative effort of technical institutes and industry. A purposeful system of industrial apprenticeship which industry, on the one hand, accepts as its primary responsibility, and that technical institutes, on the other regarded as an integral part of the total process of education, is our primary need today.

It is true that in the diploma courses only 35-37% of the total curriculum time is for theory while 63-65% is devoted to laboratory work, workshops, field work and drawing, which compares favourably with similar technical courses conducted by institutes in developed countries. But the main deficiency is that this not backed up with practical experience in industry, that is vital for producing a finished technician fit to enter upon his professional responsibilities in an industrial organization. This deficiency rises because we have not yet organized a first-rate system of apprenticeship in industry in elaboration of polytechnic education. In Germany, every candidate who wishes to enter the ingeneurschule (equivalent to our polytechnic) must have completed a two year apprenticeship in industry. In Britain, a major part of the technical college programme for the middle-level technician is organized on a part-time basis for persons working as apprentices in industry. A number of colleges also conduct sandwich courses in cooperation with industry, in which a student spends stated periods in industry and in the institutions in alternate layers. In India, our industrial organizations and other employing authorities have yet to organize, on an adequate scale, programmes of apprenticeship for young persons after they have completed polytechnic diploma courses that will condition them as technicians and back-up the educational programmes of polytechnics. On the other hand, they demand of the polytechnics that these shall produce technicians fully equipped with practical experience and ready to undertake professional responsibility. No polytechnic can meet this demand without the active cooperation of industry in organizing and conducting an apprenticeship programme as an integral part of the total process of technician training. It is, therefore suggested that reorganization of our polytechnic courses must proceed in these new directions. First polytechnics and industries that are located near each other should cooperate in organizing a conducting sandwich courses for training the correct type of technicians that industry requires. Some effort in this direction have been made by certain industries in Calcutta, Madras, Coimbatore, Bangalore and elsewhere and sandwich courses conducted by them have proved very useful. Sandwich courses should become ultimately, a general principle for all polytechnics that are located close to industry. Industry must accept as a legitimate responsibility the organization and supervision of apprenticeship training for polytechnic students.

The second criticism of our polytechnic courses are that they are still a poor limitation of our degree courses. The deficiency seems to be in the way in which the subjects are taught, the level at which they are taught, and the methods in which engineering theory is related to professional practical work. This deficiency is not integral to the structure and curriculum of the diploma courses, but to the fact that the teaching and learning processes in our polytechnic are still ineffective. It is only through better faculty development of our polytechnics and through better selection procedures of students for admission that this deficiency can be corrected.

The third criticism of our diploma courses is that they are in the broad fields of civil engineering, mechanical engineering and electrical engineering and that there is no attempt at diversification or specialization in any one particular branch of a major subject-field to train specialist technicians. This is true, but the pattern of employment of technicians in the major sections of our national economy is largely responsible for the continuing dominance of these courses in our diploma education. With the expansion and deepening of the economy, however, employers in both private and public sectors are now seeking a stronger accent on specialization. The stage has come therefore when our polytechnics in close cooperation with industry should carry out an analysis of the functions, fields of activity and typical job positions available, should identify various technician specialities and should reorganize their curricula offering to suit these. In doing so, they should bear in mind the pattern of employment in major sectors of our engineering activity, the need for mobility of technicians both horizontal and vertical and the immediate and future employment opportunities available to them. Before any of these specialities is started as a part of the engineering curriculum each polytechnic should ensure in consultation demand for specialist-technicians trained by them. Training in each speciality should be a judicious combination of theory and practical experience in the field, and where possible, sandwich type of courses should be offered.

The curriculum should give a broad-based education in the major field of engineering; and training in a particular speciality should be built on this broad base. We should ensure that if the diploma holder does not get a suitable job in his speciality he should not become unemployable as a technician, in another relevant field, and that his horizontal mobility does not become difficult. Even where sandwich courses are offered, flexibility should be allowed to each institution to decide in consultation with the cooperating industry at what stage of the course the professional practical training should be integrated with the whole educational process. Flexibility should also be allowed to each institute to decide whether the professional practical training should be organized at one stretch or given in convenient instalments at appropriate stages. The integrity of the sandwich course is best maintained by establishing a close relationship between engineering theory and its application to actual construction, production, design and maintenance of plant and equipment.

Our plan for reorganizing and improving polytechnic education will succeed only to the extent that the teaching faculty of our institutions are continuously trained and motivated for the new task. Unfortunately, the present position in polytechnics leaves much to be desired. Though the large number of vacancies that persisted in many polytechnics have to a great extent been filled the quality and standard of the teachers available have not come up to the desired level. A large number of teaching positions are held by fresh graduates with little or no industrial and teaching experience. Even among the senior staff, industrial experience and contact with the practice of engineering are grossly inadequate. These and other deficiencies of our polytechnics education need to be removed as a top priority. It may be thirty years before we can train and equip the large numbers of teachers in our polytechnics with the necessary competence to make them function better. It is inconceivable that we should have to wait so long and programmes that can give quick results are urgently needed such as organizing on an extensive scale short-term intensive in-service training courses in various aspects of polytechnic courses as also relevant practical training in industry.

Since 1951 when the Kharagpur Institute of Technology was established the faculty of IITs has grown steadily towards maturity. Between 1958 and 1962 four more IITs were established. These have made a deep impression on higher technological education and research in our country. Their graduates and teachers have earned a high reputation for themselves and the post-graduate courses and research facilities are excellent.

When the plan for these IITs was formulated by the Sarkar Committee in 1946, a distinctive role was visualized for them in training high grade engineers and technologists. There were at the time only 30 engineering colleges with an admission capacity of about 3000 students. Very limited facilities existed for post-graduate studies and research in engineering. Since then there has been a phenomenal expansion of technical education in India and it is in this situation we must consider the role of the IITs. It is not enough for these institutes to function merely as centres where students of merit go to study conventional degree programmes at the undergraduate and post-graduate levels. With their better resources and equipment, facilities including good faculties, they must aim both at academic excellence and at becoming a part of the total developmental structure of the country. They must develop a social commitment and help transform our society by applying their superior scientific and technological skills to the many problems confronting us. The research work of each institute must reach out to help in the industrial process of our economic development, and faculty and students must respond meaningfully to the challenging situations in our changing social scene.

So far each Institute has tended to function in isolation from the others - inevitable perhaps at the initial stages when each had to develop and experiment with its own ideas. But now that they have all reached maturity, it is important that they collaborate with each other, interact and cross-fertilize one another's ideas and experience. Long-range inter-institutional relationships should be established such as for example a regular programme of faculty exchange. This would help to carry the experience and ideas of one institute to another, and to undertake co-operative research programmes interacting one upon the other. The pooling of ideas and resources could make an enduring contribution to technological research and development.

We have two developing complexes - one an engineering education complex consisting of the institutes of technologies at the apex, regional and state engineering colleges and university departments of engineering. The second is a scientific complex of National Research Laboratories and other research organizations. What precisely is the relationship between these two complexes and how do they complement each other in the total process of industrial development of our country? The other important issue is - within the engineering educational complex itself, how does each component interact with the others through its faculty, teaching and research programmes and other activities. I am anxious that a coherent and integrated system of science and engineering should be developed in which the complementary roles of engineering institutions and research laboratories are clearly identified. We must recognize that the role of our engineering institutions, particularly the IITs, is not just to train engineers for employment - they must also participate effectively in the whole process of industrial development and technological advance by interacting with scientific research institutes. The IITs and the National Research Laboratories should, it seems to me, establish immediately cooperative relationships and undertake joint programmes of research, development and consultancy services in specific fields in which their resources could be pooled to the best advantage.

The cooperation between the IITs and National Research Laboratories should extent in other directions. For instance, it should be possible for a research scholar of an IIT to work in a particular National Laboratory for stated periods in a specific field and supplicate his thesis for the Masters or for the Ph D degree. Similarly, a research worker of a National Laboratory interested in working with the faculty of an IIT should be provided with opportunities to do so. Only through a continuous exchage of faculty members and research workers by pooling resources and expertise and working towards common objectives can the IITs and the National Laboratories complement one another.

There are many problems of technological development in India for the solution of which the IITs and the National Laboratories cooperating with one another can render invaluable service. This can be done in the process of development and technical know-how for fertilizer production, metallurgical products, design and fabrication of manufacturing plants and equipment, electronics and radio engineering. Though large fertilizer complexes have been set up, both in the private and public sectors, many plants are working far below their rated capacity affecting adversely the supply of much needed fertilizers for agricultural development. There are many technical problems associated with the low productivity of our fertilizer factories. The IITs which have first rate chemical engineering departments should pool their expertise to study the problems of fertilizer production and provide a comprehensive solution to the industry. If they undertake a major responsibility of this kind they will make a deep impression on industrial development. Similarly, the departments of metallurgy and mechanical engineering at the IITs in cooperation with the National Metallurgical Laboratory should carry out a comprehensive study of the problem of metallurgical production and processing to improve the efficiency and productivity of this industry. The IITs and National Laboratories should in collaboration, set up pilot plants for the application and development of scientific research in industry.

Equipment facilities available at different IITs which are specialized and expensive should be pooled and shared and as a beginning a consolidated list of specialized equipment available at each should be made and circulated. A research worker needing equipment not available in his institute, should be enabled to use such a facility available elsewhere. Highly specialized and sophisticated equipment need not thus be duplicated. Similarly a library catalogue of all the literature available in various IITs should be prepared and widely circulated and a free exchange of books be made possible. In the design and fabrication of laboratory apparatus and equipment also the IITs should play an urgent role.

Such design and fabricating units, producing indigenous equipment have been set up at some IITs. Unless we are independent of imported equipment our engineering education cannot make much headway. The IITs should discuss with the representatives of scientific instruments industry how to develop this work on a planned basis. A complete documentation of the scientific apparatus and instruments produced by them should be available along with how they could be used. Each Institute, engaged in this activity should set up a museum of scientific instruments and apparatus.

We have recognized the importance of bringing science and technology together to make them interact in technical institutions. Yet not much has been done in this direction. Most institutes are content with setting up departments of physics, chemistry and mathematics and teaching these subjects in the curriculum of the four-year degree courses. This is not enough. The IITs should organize engineering degree programmes of a high standard for science graduates.

The IITs should assume the responsibility for improving engineering education by reaching out to help other engineering institutions in their respective areas. Each Institute should undertake a comprehensive programme of faculty development and organize in-service training for serving teachers, summer institutes and short-term courses. They should pool their resources and undertake programmes of curriculum development, preparation of instructional materials, including text books and reorganization of laboratory experience. They could also send out their first-rate senior faculty members to engineering institutions for stated periods to set up, rouse and emulate the world's highest standards. A 'sisterhood' arrangement should be possible between each IIT and a group of engineering institutions in the area. In addition to serving industry through consultancy, research and other programmes, the IITs should service other engineering institutions wherever their assistance is needed. Only thus can the IITs fulfil their role as apex institutions. Such inter-institutional relationship should also extend to students, the best of whom could be brought from engineering institutions to the IIT compus in the area to expose them to the academic and research atmosphere prevalent there. The best of these students can be marked out by the IITs as prospective entrants to their post-graduate courses or research work.

In the establishement and development of the IITs, we have had valuable assistance from the Soviet Union, the Federal Republic of Germany, the USA, the UK and so on. These Institutes represent an enormous enterprise in money, materials, scientific personnel and international collaboration. This vast system should function effectively and harness its energies for our national development. It is seen that a large proportion of the best graduates in science and engineering go abroad for higher studies and research and for employment. While higher studies and research abroad are legitimate ways of acquiring better knowledge and skills, our IITs should not become a training ground for the export of our scientific talent to other countries. These graduates have a debt to pay to the society that has educated them, by working for the reconstruction of its economic life. The government and the public have also a responsibility to provide a congenial atmosphere and prepare conditions of service for technical personnel to function creatively and derive satisfaction from that work. No country has become rich without the dedicated work of its own people. The IITs and its alumni have to become an integral part of our social structure with a commitment to our poverty-ridden and handicapped people.

I shall now spell out in a little more detail some ways in which technical education may be related to and helped by industry for there is a great need to correlate development in scientific research with technical education involvement of industry in both scientific research and in technical education. The involvement of engineering and research institutions with industry is even more important at the research and post-graduate stages of education because it is at those stages that the problems of industry requiring research need to be undertaken by technical institutions.

Simultaneously, it is also important to establish and activate adequate communications and liaison between our technical institutions on the one hand and the Small Industries Service Institutes, State Departments of Industries and Nationalized Banks, on the other, with a view to promoting opportunities for entrepreneural activity on the part of our engineering students who are graduates and diploma holders. Discussions should also take place at local and State units between these bodies and a suitable machinery devised for giving, at the student-stage itself, information on likely opportunities and then following it up with helping to find technical, financial, and other assistance to those graduates or diploma holders who would seek to start small units of their own. It would be useful for the Institutes of Technology to set up small cells to coordinate this effort and assist the graduates in a wide range of schemes of self-employment. It is suggested that we utilize all work-shops, laboratories, drawing halls and the faculty of the technical institutes in a large industrial movement to re-shape and re-vitalize the economic life of our country. The institutes of Technology, which have always functioned as model institutions, should set an example to all other technical institutions in this matter.

Another way of getting industry to implement its role in technical education is to provide for training facilities on the job for engineering graduates. In fact, such a system is already in vogue in the United Kingdom where an engineering graduate cannot claim the status of a professional engineer unless he has undergone such a period of training in industry after his graduation and also held a position of responsibility for a given period, thereafter. The object of the graduate training scheme from the point of view of the employer is to attract young engineering graduates of promise and train them for positions of responsibility in the firm. The training is mainly by doing rather than by looking at or listening to as far as possible. The trainess are given salaries appropriate to their qualifications, and courses are generally given in mechanical, electrical and producting engineering. The training period is divided into four parts. It starts with an induction period, and is followed by a period of basic training which is intended to give the student a sound understanding of the tools, equipment and basic engineering practices of the industry. This is organized in the Company's training school and/or machine shops. The next stage is the period designed to give all the students basic experience of the factory floor and the production methods regardless of their ultimate sphere of activity. By working in close association with the production engineers, to whom the student is attached during the period of training, the student gains experience in production, assembly, fitting shops, tool room and inspection departments. The course thereafter divides into specialized fields of activity such as production, design and development, commercial (sales and buying), work engineering or research and the student takes up the course appropriate to his chosen field. This consists of specialized periods in offices such as tool drawing office, process planning, design office and estimating and further training in specific departments. Thus for design and development, the training will be in experimental and test departments; for research, it would be in research laboratories, and for works engineering, in buying and contract departments. The course is so designed that the graduate spends the last part of his training in the Department in which he hopes to work, thus enabling him smoothly to take up a job when a suitable vacancy occurs.

These training programmes operated by industry were not uniform in quality and indeed many firms did not have such programmes. An Industrial Training Act was therefore passed in 1964 which placed on industry firmly and clearly its responsibility for providing training within the domain of employment, as a supplementary educational process for academic technical education. The act empowers the Minister of Labour to set up Industrial Training Boards for ensuring that the quantity and quality of training is adequate to meet the needs of industries for which they are established; and by March 1966, such Boards had been set up for more than 16 industries. The Boards are obliged to impose a periodic levy on employers and have power to make grants to those whose training courses are approved by them. These levies are calculated as a percentage of the total annual salary and wage bills of the industry concerned. In the case of the engineering industry, for example, the levy is at 2½% and amounts to an annual figure of more than £ 70 millions.

The Training Boards consist of representatives of employers, workers and of educational institutions, with a Chairman appointed by the Minister for Labour. The Act makes it obligatory for employers in the industry where an industrial training board has been established to furnish returns and keep records on their training programmes and produce them for examination by the Board or its nominees. Grants are made to the employers whose training programmes are found to be satisfactory, while for the others who have either no training programmes or have unsatisfactory ones, the levy becomes a net charge on their resources. Thus all industrial employers are obliged to pay for the post-academic training of engineers and technicians, while those who undertake the training programmes receive grants for the purpose. In order to ensure that the training programme is of the appropriate character and the right quality, it has been provided that a training programme cannot be operated by any Company or firm unless it has a Director of Training with a proper status in the employers' hierarchy. In view of the dearth of competent training specialists for the purpose, provision has been made for the organization of short intensive full-time courses for the training of prospective training officers or Directors of Training; and these courses are being organized with the cooperation of technical colleges and colleges of advanced technology. Under the Boards there are a number of Inspectors who have the right to investigate what is happening inside industrial concerns and finally approve or not approve the training.

The industrial training, which has now received statutory recognition and compulsory financing in the United Kingdom, is clearly a recognition of the role of industry as a partner and participant in technical education. It is to ensure this and effect proper coordination between the needs of industry and the academic programmes of technical institutions that the Boards include academicians as well as industrialists and working engineers in industry. Therefore the implementation of the Act is a joint responsibility of the Ministry of Labour and the Ministry of Education and Science, and each Board has associated with it Committees which are jointly representative of education and of industry to formulate the programmes and the courses which should go with these programmes. The role of industry in technical education is further illustrated by the practice followed by the Imperial College of Science and Technology, London, in its department of Electrical Engineering. This department has a number of special lecturers drawn from industry. These men spend one day a week in the department, not only participating in its teaching work but also discussing with the staff what should be taught, how it should be taught, and how what is taught is related to what is happening in industry. The full time teachers themselves are also encouraged to obtain industrial experience and thus impart a practical bias to their teaching by being permitted to function as Consultants for small or large industrial establishments or enterprises in the public sector. In special cases, they are also encouraged to go back to industry on a full time basis for some months or even a year at periodic intervals. Thus a serious and systematic attempt is being made in the United Kingdom to evolve a working partnership between industry and the academic world for the reorientation of technical education to make it more practical and better suited to serve the actual needs of industry.

We have for long stressed the need for technical education and industry to cooperate closely. We have urged that experts from industry should work as part-time lecturers and that our faculty should go out into industry to give a practical bias to their expertise.

Time is an important factor in a developing society. We have to do in five years what others have done in 50 years. What has been done in agriculture by the green-revolution can also be done in industry especially in the realm of small industries and in an extensive manner over all areas of the country, provided we go in for a bold and imaginative programme of public works in the rural sector. Rural roads, culverts and bridges, rural school building programmes (a large number of our primary schools today are either without buildings or are otherwise housed in most unsatisfactory conditions), low cost housing in urban areas accompanied by slum-clearance, and other construction work can be undertaken on a planned and massive basis in the next four years. The economic situation is favourable for launching such a programme. Food supply is growing; there is surplus capacity in cement; it is not difficult to increase the supply of other materials needed for construction and road building, and technical skills, are available in the shape of unemployed engineers, diploma holders and other educated supervisory and auxiliary personnel.

The heart of the problem of improvement in quality lies however in effecting a radical change in the content of engineering education in respect of practical training and relation to industry. Engineers are required for service in the current operations of industry, using the expression in a broad sense, of using power, machinery and materials. The engineer's major role is to design, organize and create or practise an art based on science. While undoubtedly he must have sound theoretical foundations and adequate knowledge of the relevant scientific principles and academic disciplines, it is in application, improvization, and organization that his speciality lies. At the same time, it is not possible to convert engineering institutions into factories or give them workshop floors or endow them with other components of actual industrial experience. Work in a laboratory is extremely useful for learning principles and giving them visual reality; but it is no substitute for getting knowledge and the ability to handle the many snags and problems that arise when applying these principles to the concrete problems of production in the real world. Industrial experience, in a more than laboratory sense, is a continuing stage from academic instruction and laboratory experience in order to complete engineering education. And industry, and the industrial unit, firm or factory, has to play an educational role and function, alongside its normal activities, also, as one among the tier of institutions that constitute the educational structure for producing the complete engineer. This responsibility of industry as a partner and participant in technical education is well recognized in many of the developed countries. It is high time that similar recognition is given in India as well.

How this is to be done and what precisely is the role that industry can play as a continuation of the engineering education that is given at the academic level is a question that needs detailed and expert examination; and this needs to be jointly undertaken by both the educational and the industrial authorities. The system of sandwich courses has the disadvantage of breaking up academic continuity and saddling the employer with trainees over discontinuous periods from whom he may not get any permanent advantage. When the sandwich courses are taken by his permanent employees, however, these latter disadvantages get neutralized and they can be most successful in producing engineers with practical experience, theoretical foundations, and skills suited to the needs of their employers.

An alternative to the sandwich courses but closely approximating to it is the 'cooperative' arrangement for technical education that is emerging in the United States. Thus, for example, there is the General Motors Institute at Flint, Michigan, which gives a first degree in engineering. Here the students spend alternative periods in the Institute and in the adjacent plant. The ground covered is the same as in engineering courses in American universities, but with the difference that in the later stages, the 'core' subjects are augmented by elective studies related to the interests of the firm. But the degree is not awarded till the students spends one year of full time employment in the plant and also carries out investigation on a specific problem under the guidance of a 'plant adviser' and an 'Institute Supervisor'. A variation on the same theme are the higher technical establishments run by industrial plants in the USSR. These institutes are staffed by regular teachers from the higher technological institutes, while part of the instruction is provided by suitably qualified staff within the plan, students are all full-time employees and are given lectures and tutorials partly during working hours and partly outside working hours, use being made of equipment within the plant to the extent feasible. This part-time instruction within the plant and its institute is supplemented by stretches of instruction at the normal higher technological institutes, amounting often to as much as five months within a year, during which period the student receives his full pay. Even in the case of the normal higher technological institutes, facilities are available for 'production training', with members of the staff often holding double appointments, one with the Institute and the other with industry. In effect, this offers students facilities for specialization in what is really a combination of a technical university and a research establishment linked with and often working for industry but not within it. The outstanding example of such an institution in the USSR is the Moscow Institute of Power Engineering. Of course, the USSR, model is preeminently suited for a country whose industries are in the public sector. Now that we have such a large public sector in India and with prospects of continuous expansion, there should be no reason why attempts should not be to follow the USSR model for combining theory with practice in technical education and especially so in the fields of engineering related to power, steel, transport, and machine building.

By and large, however, these expedients cannot solve the problem of practical training in the major part of our system of technical education. The bulk of our engineers are bound to be Graduates of Colleges, Institutes, and Universities, who have received full-time academic training with its inherent bias for theory and non-involvement in the practical problems that face engineers in employment. Sandwich courses, plant institutes, and cooperative arrangements cannot meet the requirements of the bulk of their number. What is required for them is one kind of a follow-up course after graduation, which will be devised jointly with industry, is largely operated by industry, and gives them the industrial experience that will complete their engineering education and qualify them to be fullfledged professional engineers. The best way to do this seems to me to be some kind of 'matching education' to be given by industry as a follow-up to the university education given by the regular engineering institutions.

The 'matching education' which is proposed should include a short course in manufacturing engineering or the choice of materials for a given purpose and their manipulation into required shapes. In effect, this means materials management, but, not in the abstract or in the aggregate but, in concrete terms and specified fields related to the industry in which the graduate would like to seek employment. It is important that the courses offered are conducted by a highly qualified staff who would command the graduate's respect, and are given in an academic setting either in a local college or university or in an industry. This should be followed up by group projects, which would mean some money and access to the facilities of the firm, involve both designing and manufacturing, and be a microcosm of an actual industrial situation. In such a group project, the participants have to organize themselves, delegate activities, and apportion money, time and skills. In effect, they would have to manage a technical-cum-machine-cum-human complex; and nothing would give them a better understanding of the actual problems they will have to face and deal with, when they enter into full-time industrial employment or set up an individual or joint industrial unit on their own. It will satisfy the graduate's desire to do something concrete and constructive, and give him an opportunity to use his academic training and convert ideas into hardware. It seems to me that there can be no better way than the group project for inducting the academic graduate into the realities of manufacturing discipline. Such a concept is already in use in institutions of higher management and of staff courses for military personnel. There is no reason why it should not be introduced into the field of technical education, and thus bridge the gap between theory and practice which is so badly needed in our country.

So much for the general practical follow-up for all engineering graduates with the joint collaboration of the academics and the industrialists and the active cooperation of the industry or its component firms and factories. The supply of graduates should dovetail with the specialized requirements of industry in such a manner as would combine theory with practice. The emphasis in the instruction must always be on relevance and realism, backed up by demonstration of existing practices and case studies drawn from real situations. It would be worthwhile for Indian industry and those controlling our technical education to examine the feasibility and practical implications of setting up such joint centres for specialized training for our engineering graduates.

The disturbing fact however is the problem of unemployment among our engineers. The number of engineering graduates and diploma holders on the live register of employment exchanges as on June 1976 was 16 888 and 55 232, respectively.

The problem is being tackled from the angles of both supply and demand. The Central Government has been announcing a series of special measures to increase demand. These measures included the employment of engineers for preparatory investigations for irrigation and power projects, road transport development, soil surveys, etc; employment of engineers for the operation and maintenance of thermal power stations; employment of engineers in vacant posts in various organizations including Short Service Commission in the Defence Services; development of Indian Consultancy Services; employment of engineers by private contractors; and formation of cooperatives by engineers to undertake construction work and to render servicing facilities for agricultural machinery in rural areas.

The State Governments, too, are taking vigorous steps to help engineers form cooperatives and to set up small and medium-scale industries. Many, through their industrial development corporations, have helped engineers to set up small and medium-scale industries of their own. Steps have been taken to reduce the supply of engineers and diploma holders. The purpose should not be so much to reduce new admissions as to improve quality of engineering education by making more adequate facilities available to those admitted. Engineering manpower requirements are bound to grow, with the recovery that is taking place in the economy. What is needed is to take full advantage of the pause to improve the standard of engineering education, upgrade the quality of engineering degrees and reinforce the element of practical training behind our diploma. Above all, we have to create among our engineering students and graduates a new climate, of preference for self-employment and entrepreneurial activity over their current absorption with pay-pocket jobs and reluctance to take the risk and undergo the teething troubles associated with the setting up of new enterprises. To do this, we have to give a new orientation to our engineering education, so that new graduates will have the skills, the incentives and the facilities to enable some at least among them to set up small manufacturing or consultancy or servicing units of their own, either on an individual or on a cooperative basis. This means that we have to reorient our courses, survey the industrial potential of specific areas, and guide our students on how to exploit this potentials. Markey surveys need to be conducted for various products; project reports prepared to set up units to manufacture these products, and advisory services constituted for the benefit of students. This is rewarding activity for teachers too, for it will help to complete their own practical education in creating a new industrial attitude in themselves and their students.

It is also possible for the engineering institutions directly to find employment for their unemployed alumni by giving them facilities to use the under-utilized capacity of their workshops and engineering equipment for manufacture or servicing operations and canvassing orders for them from industries in their neighbourhood. In fact, an experiment on these lines has been started in Tamil Nadu in their Polytechnic in Madurai. There are also ample opportunities for the employment of self-employment of engineers and diploma holders in servicing the rural population who are now participating in the green revolution and are using tractors, power tillers and pump-sets. The Karnataka Government has embarked on a scheme under which they are setting up in each district a tractor servicing and tractor hiring centre which gives employment to one engineer and two diploma holders at each centre.

At present the spectre of unemployment haunts many of our engineering graduates. Most of them have been trained for jobs in big factories, government departments and scientific organizations. When those jobs are not available, they tend to get demoralized and start feeling that they are unemployable. With bank nationalization and the new policy of economic dynamism, credit and other facilities are becoming available for young engineers who want to start on their own and work for themselves. What is needed is a training that will impart such self confidence to the engineering students. Job orders can be secured from local industry for such products as bolts and nuts, making fastners and components, cross arms for electric poles and small structural fabrications. Raw materials can be provided; the products produced can be sold to industrial organizations in the locality. Some institutions like the Madurai Polytechnic as referred to earlier have taken up such schemes and the result is that participants under the scheme have grown self-confident and have been able to set up small workshops or repair shops of their own to become self employed. There is no reason why this experiment cannot be extended to all our Polytechnics and engineering colleges in a big way.

Jobs cannot automatically be created for engineers. They can emerge only as a link in the chain of economic development. We have, therefore, first to increase productivity, because only through productivity will we have a surplus for reinvestment. As increasing investments are made, increasing employment opportunities are generated. The primary task of our engineers and technicians is to accelerate the pace of production. In this enterprise, the universities and Institutes of Technology can find opportunities of valuable experience both for their initiative and example, they can break forever the isolation that tends to divide learning from the lives of the masses of the people of India. If our universities can function as centres where students of merit may go to learn, not merely the theory of engineering but its full psychological implications, namely, our social commitment that will transform our society, they will have served us in the Age of Science.

We in India are confronted with a paradox. We have been drawn into the revolution in science and by inference into the technology that has changed the face of the world and expanded industrial development.

Time is of the very essence and we have to do in a hurry what other societies have done more slowly, in the course of long drawn out industrial revolutions. In this age of highly industrialized competition we cannot afford to lag behind, and it is quick revolution, not slow evolution that we need.

TRAINING OF ENGINEERS IN UP

A C Chaturvedi*

Engineers have to shoulder social responsibility, involving first and foremost, the consciousness of the obligation to serve society with dedication and integrity and to the best of one's ability.

The courses in the polytechnics should have many diversities and better linked with the requirements of the industry and the project where the students work. Such boys may also be given preference in degree course but should persue a special short term course of studies.

The degree student should acquire proficiency in construction, management and operation of electronic equipment. They could be taught ordinary design and specialization may come later. The training at the first degree level should be highly specialized. It is necessary to have equal emphasis on science and technology. Great emphasis should be given to teaching practical side of the science.

INDUSTRY

Engineers going to Industry should be given a two-year training in small scale industry like production engineering, labour management, etc, packaging and advertising, publicity and materials purchase and handling, industrial psychology planning and layout of factory building power supply and distributions. The speciality and the students should be called upon to submit a thesis of a project report.

The research student should have the capability to do original work of a high order and capable of guiding research. They should also be capable of making out an ingenious design of an equipment or a project based on years after working in the field. The research Institutes should start their training at the under graduate level. Their function can easily be enlarged. Even graduates in engineering can be trained to a six-year course for D Sc (Eng) course, the first 3 years being devoted to basic engineering, the next two years to research and the final year for completing thesis.

The students will acquire proficiency in material science which is an interdisciplinary subject and owes its development to researches in fields of metallurgy, chemistry, solid state physics, ceramic, etc.

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The present day indigenous capability, if properly pooled and guided with the necessary provision of financial resources, it can fruitfully fulfil many of the national requirements. The R and D projects undertaken should bear a direct relevance to the programmes envisaged in the socio-economic framework of the plans.

TRANSFER OF TECHNOLOGY

The horizontal transfer of technology within the country, which requires a regular flow of information from our R&D establishments to the people at large, has been found to be lacking much. It is essential that an effective system of interchange of technological experience should be developed between the R & D establishments (either within the industry or research laboratories) and the people using the research results. It is also important that we should effectively process, store and disseminate the rapidly growing and accumulating technical information and data around; but more importantly, this information should be capable of stimulating interests and demands. This necessitates: (a) provision of facilities for training scientific and technological personnel in the methodology of technology transfer, (b) development of systematic and (c) strategies for adaptation of technology.

BENEFITS

The future course of action in the R & D efforts in engineering is quite clear. It would be towards the development and utilization of yet more technology so as to ensure the benefits of the modern civilization to all people, besides also ensuring a stable ecological equilibrium. There is no question of retreat from technological research. If there is any failure on our part to provide adequate training to a large number of engineers having diversified professional interests (some of whom are functioning at the specialized uni-disciplinary domains and many others are functioning at the trans-disciplinary frontiers) and to keep on updating them, the adaptation of technology for societal causes cannot be satisfactorily achieved. This, therefore, leads us to the problems of continuing programmes that become necessary for retraining and updating of the members of the profession.

Continuing education programmes may be conducted with a view to assessing their impact on the profession. The feedback from these courses is impressive and such courses should be made a permanent feature of activity-pattern and specialized training should now be planned and established to coordinate such activities, particularly to encompass the interdisciplinary and transdisciplinary domains.

FINANCING PATTERN

The magnitude of the projects in developing countries almost invariably involves enlisting several sources for financing and what sources qualify in a given case depends on the nature of the project. Basically, there are two categories of projects. The first category comprises projects launched by the government. These usually consist of the infrastructure.

It is necessary to set up an International Foundation for Technological Corporation aimed at marshalling foreign Scientific and technological resources to help accelerate the development process in the third world. The foundation may not only aid the developing nations, but also reopen possibilities of two way scientific exchanges with the advanced nations. Third World Leaders have been pressing for a long time for easier transfer of technology. The foundation has to carry scientific and technical knowledge to the poorer nations. The foundation has to cater to the unfortunate millions in the less developed nations of the globe including India.

COOPERATION

Cooperation of Universities may be sought to popularise improved designs in housing. As these universities play a pioneering role in integrated rural developments it may be suggested to them to put up for demonstration, low cost reveal houses on the campuses. Such construction may attract a large number of rural visitors, especially during fairs.

The agricultural university in the state of Gujarat has already set up a cluster of houses based on the designs evolved by the Vallabh Vidyanagar wing of the National Buildings organization. Other rural Universities should also come forward with similar prospects.

PERIODICAL COURSES

The main wings of the National Building Organization and the Central Building Research Institute, may be located in various engineering colleges in the country, conduct periodical training courses for technical and other persons engaged in rural reconstruction. More than 3000 persons may be trained annually.

The wings may also prepare various house designs on data based on social and economic surveys conducted in a group of 100 villages. The designs to suit local requirement may be sent to State Governments and agencies. The wings may suggest new improved construction techniques and use of local material including stabilised soil construction, water proof mud plaster and fire retarding treatment for mud roofs.

TRIBAL WELFARE SCHEMES

Training need to be imparted to bring all the land in the eight tribal development agencies under various improved agricultural techniques and to settle landless tribals and to construct link roads and arterial roads.

REFERENCES

1 Taylor, John L - Instructional Planning System - Cambridge University Press - 1970.

2 Spicer, Edward H E - Human Problems in Technological Change - New York-Russel Sale Foundation 1952.

3 Sperling, Jan - The Human Dimensions of Technical Assistance - Ithaca, New-York, Corness University Press 1969.

4 Clignet, Remi and Philip Foster - The Fortunate Few - Northwestern University Press 1966.

5 Wilson, Raymond R - Forwards a Philosophy in Planning Report no EE P 42 - Stanford University 1971.

6 Rogers Everelt M and F Floyd Shoematxer - Communication of Innovations - New York, Free Press 1971.

7 Ohm RE -- Organisational Goal: Educational Administration Conference - University of Oklahoma - 1969.

EDUCATING ELECTRICAL ENGINEERS OF THE FUTURE

Prof Om Parkash*

ASSESSMENT OF REQUIREMENT

The future requirements of electrical engineers is going to increase considerably, due to rapid industrialization, automation and use of sophisticated devices etc. The manpower required to perform the electrical engineering jobs in the future, say, in the 2000 AD, will have to be properly assessed. This assessment has to be realistic. After making such assessment the requisite manpower will have to be suitably trained.

TRAINING

The method of training could be either formal or non-formal. Formal method of training may not be suitable in all the subjects to be covered for the students. A number of engineering problems can be learnt by the students only through direct practical experience in the field. Therefore, the students should be sent to industries, power houses, R&D Organization, etc for getting work experience. This attachment should be done, as far as possibly every year during their course of studies. Such attachments have to be carefully planned.

PROJECTS

The students of the final year should be asked to undertake project work. The topics for the projects should be selected in consultation with industries. If the selected project is relevant to the needs of the industry, then student expertise can be so developed as to reduce on-the-job training period in the industries. If the industry sponsors a project, then more time will be available to plan and execute the same.

TRAINING AIDS

Mere use of blackboard and chalks is not sufficient to impart training to these students. Therefore, carefully planned charts, slides, films, audio/video tapes, cassettes etc, should be used to supplement the lectures. At present a number of engineering students are still using slide - rules for computing purposes. However, in future electronic pocket calculators should be used. One may go a step further and advocate the use of digital computer as a training aid. Such computers are being used in many engineering colleges and universities in foreign countries. A number of projects in computer aided instruction are currently in progress in many well known foreign universities. Similar projects can be undertaken in India also.

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CURRICULUM DEVELOPMENT

The various stages of curriculum development are :

(a) Gathering information regarding needs (that is projected needs of the country and manpower requirements), inputs (students' characteristics and proficiencies, faculty qualifications and experience, physical resources) and output feedback (comments from industrial and other employers, ex-students and evaluators).

(b) Formulating goal and objectives of the course, on the above information and preparing a provisional curriculum.

(c) Validation of the provisional curriculum by experts from industry and academic institutions and

(d) Implementation of the new curriculum and continuous evaluation and modification during the course of implementation.

Of course it is difficult to decide the exact contents of the curriculum for electrical engineers of the future. The difficulty arises due to the fact that both the available knowledge and needs of the society are changing at an explosive and hitherto unprecedented pace, due to intensive R&D efforts all over the world. An education system should therefore be amenable to changes at a pace which is commensurate with the rate of further technological developments. Thus, we must have flexibility in our educational methods and rectify any causes, however time honoured, which inhibit change when it is necessary.

The electrical engineering student of the future will be expected to know more about neighbouring disciplines than the present students. Thus the students may be required to know more about physics and mathematics. He should know more about Boolean algebra, Laplace Transform, Theory of Sets, Algorithm Techniques, etc, which are more relevant, than much about statics and dynamics of rigid body. They should learn more about the new emerging technologies like bioengineering, power electronics, lasers, computers, environmental engineering, non-conventional energy sources, operational research etc. In order to reduce the overall-burden, redundant portions in the existing curriculum may have to be cut down.

METHODS OF EVALUATION

The methods of evaluating the engineering students of the future may have to be suitably modified to meet the requirements of the future. Instead of adopting the formal methods, the methods of continuous assessment of the students, award of grades instead of marks, objective types of tests, assessment by the employers etc, may be adopted.

TRAINING OF FACULTY

In order to impart proper training to the engineers of the future, suitable faculty has to be generated. Unless we have properly trained faculty, the future engineers will not be able to get proper training, even if all other measures are adopted with great care. For training of faculty, suitable methods of selection of teachers, their training, utilization, career planning etc will have to be evolved. For this purpose closer liaison should be there between the training institutes and industries as well as R&D Organizations, by exchange of staff, etc.

TRAINING AND MANPOWER DEVELOPMENT FOR NUCLEAR POWER STATION

Ramalingaiah Padala*

NUCLEAR TECHNOLOGY

India's Nuclear Power Programme envisages in its first phase the building up of natural uranium fuelled heavy water cooled and moderated reactor plants (PHWR) for the production of electricity. One unit of 220 MW is operating in Rajasthan since 1972 and another unit is being commissioned. Four units of 235 MW each are in various stages of construction at Kalpakkam and Narora. These plants need only indigenously available natural uranium fuel and their total installed capacity amounts to 1380 MW in addition to the operating enriched uranium power plants of 380 MW in Tarapur.

It becomes apparent that the manpower should be geared to take up the challenging tasks of operating and maintaining a nuclear power plant. As this industry is new, manpower with the required knowledge and skills in many categories is not available and therefore, engineers and other technical personnel should be educated at the jobs to develop the required degree of proficiency and skills.

TRAINING AND DEVELOPMENT

A Nuclear Training Centre (NTC) has been set up in 1968 to meet the manpower demands of the present and future atomic power plants.in the NTC Organizstion for Training. The training programmes have various phases of training for the different categories of personnel as- recruited from thermal power stations, research reactors and other industries as well as fresh persons from the institutions.

After assessing the needs of an individual (in case of specialized training) or a group, suitable training)programmes are drawn with the consultation of the Section Heads. The responsibility of training and performance evaluation does not depend entirely on the training centre but equally depends on the Section Heads during the on-the-job training.

The training philosophy is to take the trainee into confidence, explain, demonstrate and allow to do and finally assess. Another aspect peculiar to a Nuclear Power Station is to impart training both on Nuclear as well as on Conventional areas in order to check man-rem distribution. The effectiveness of training depends not only on the trainee's response but also on continuous guidance by the trainer through feedback. These factors improve the ability of an individual to achieve better performance in the plant thus paving way for one's career advancement and the development of the organization as a whole.

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* Rajasthan Atomic Power Station, Kota.

The programme initially consists of 6 months plant systems study including conventional and radiation protection training with plant visits followed by 18 months on-the-job training in the relevant areas. However, the levels of training are different. Qualification programmes are carried out to qualify operating personnel who possess 4-6 years of working experience in the station for the posts of Shift-Charge-Engineers and First Operators.

The training facilities available are lecture halls with audio-visual equipment, library, maintenance training shops for Control, Electrical and Mechanical disciplines and Radiation Safety Laboratory. The materials used for training cover a wide range of topics which emphasise plant systems and equipment at different levels for the various categories of trainees. Reference documents such as Commissioning, Unusual occurrence and In-service Reports are used for widening their knowledge.

During the training period at NTC, written check-out is held on completion of each course. Oral test is carried in addition, in case of system courses. A combined assessment of the trainee is done after completion of all courses by the Training Officers and grades are maintained. Depending upon performance, aptitude and the availability of a vacancy a fresh trainee is posted to either Operation or Maintenance section for the on-the-job training. At the end of one year he is interviewed by a Committee of Senior Engineers to assess performance, and to give grading in confidential report. Yearly reports are reviewed after the first 3 years and every year thereafter for developing career.

NTC - 'TURN OVER'

The trained manpower has increased ten-fold to 460 by the year 1977 for both the units of RAPS. The above figure includes about 20 Qualified Shift-Charge-Engineers and Qualified First Operators. About 180 technical personnel in various categories of the Kalpakkam Atomic Power Project have undergone training. In addition to this personnel from other sections, industries and countries underwent Station orientation/specific training for various periods.

SIMULATOR - A NEW TRAINING TOOL

Training requirements for a first operator who mans the main control panels cannot be fully met from the on-the-job training even after a long time. It is neither possible to demonstrate to him as and when required the plant startup or shutdown nor to make him see the consequences of a mal-operation in an operating station as it would amount to tripping the plant or result into a worse incident. A Nuclear Power Plant Training Simulator (NPPTS) is being built indigenously as the trainee can be demonstrated and given practice for normal startup, fast startup, shutdown and emergency drills. Mal-operation and their consequences can also be shown. The simulator is the exact replica of the station control room and the simulated operations will have real times as that of the plant.

MANPOWER - 'AN EXPORT COMMODITY'

Strategies for technical manpower requirements to meet rapid industrialization with changing technologies should be taken up at National Level. It need not limit to power sector alone but other industries as well require personnel in areas like engineering, construction, operation and maintenance. A professional body of Engineers like the Institution of Engineers (India) or any other Institution should take up the responsibility of training and certifying the personnel with the close collaboration of industries. This will generate in large numbers the required degree of proficiency and skilled personnel to meet the needs of the various industries.

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APPROPRIATE TECHNOLOGICAL EDUCATION

Dr R Nagaraja*

INTRODUCTION

The absence of trained faculty in the country compelled sending engineers for higher training to the advanced nations of the west and particularly the USA. That was the time when technological education in USA was undergoing significant changes, initially guided by the lessons of the second world war and later by the Defence Education act, which had set the landing of man on moon by 1970 as a National objective. Due to these influences the Engineering courses in USA had gone highly theoretical orientation to the trainees which consequently influenced technical education in India. The result was the production of Engineers who were good in theoretical engineering but ignorant of the problems of rural India.

The expansion of Technical Education extended into the formation of the many Regional Engineering Colleges, Government and Private Engineering Colleges which more or less followed the guidelines set by the IITs.

PRESENT STATE

With increasing sophistication in technology the faculty, constantly achieved 'modernization' of the various courses often at the cost of basic, practically-oriented engineering subjects. In the field of Civil Engineering one is more apt to find a fresh graduate quite confident in analysing a suspension bridge, for which he may not have an occasion in his lifetime, than detail the reinforcements for a simple structure.

Our national need for the many years to come would be the socalled 'Barefoot Engineer' well versed in the engineering problems generated by the country's political philosophy.

The engineering curriculum of today needs to be enriched by the addition of Engineering Extension in order to give the much needed practical bias to the class room learning. This will further educate the engineering student about the problems of the neighbourhood and the country side. A similar advantage could be availed through the National Service Schemes.

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CONTINUING EDUCATION

Under the Socio Economic conditions prevalent in the country the first option of a fresh graduate is employment. Even among those who choose higher studies the drop out rate is alarming. Under these circumstances the continuing education seems to be the optimum solution. While any university can organize continuing education courses it would be highly useful if the university, the Industry and the professional bodies collaborate in upgrading, updating, broadening and diversifying the knowledge and skills of today's engineering manpower. Continuing education can also take the shape of correspondence courses leading to formal degrees or otherwise.

THE OPEN UNIVERSITY

Though the concept of an open university is recent, its principles were in operation in India for the last many years. The rural broadcasts of the AIR to farmers on agricultural problems and lately the satellite Instructional Television Experiment are only small and informal applications of the principles of an open university. The possibility of a formal open university in India is very real inspite of formidable difficulties in view of several long range advantages.

INTERACTION WITH SOCIAL SCIENCES FOR PROGRESS OF ENGINEERING

J P Datta*

INTRODUCTION

While an objective study of these interactions would fall within the domain of Sociology, itself a Social Science, which is becoming more potent as the complexities of modern civilization increase, a professional engineer would do well to look more closely now at some of the more established applied Social Sciences which concern him in his day-to-day life.

The number of engineering projects which never reach Society due to their failure to overcome the commercial barrier is legion. How many creative engineers find, to their disappointment, that mere technological feasibility is of little avail without attendant economic viability which in turn depends on regular supply of raw materials and services, availability of necessary human skills and ultimate market acceptance.

Yet, another group of energetic young engineers come to early grief through their own lack of awareness of motivational factors which harmonise collective human behaviour towards productive endeavours.

Some of the applied social sciences which might help the engineer to overcome these limitations are discussed in this paper.

ECONOMICS AND ACCOUNTANCY

A Rupee cost is a common measure of resources and products readily understood by all. Therefore, except for a rare technological break-through here and there, an engineer who presents the benefits of any engineering work in the language of accountancy has a better chance of acceptance over a colleague who has tried to establish the superior claims of a competing project mainly by technical data; even though both projects might have been comparable in real terms. Subsequent to acceptance, the engineer with a working facility with accounting techniques is able to better utilize the powerful quantitative methods of modern management information systems for managing successfully within the framework of socio-economic stability.

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PERSONNEL RELATIONS

While the physical contribution of man in any engineering system has gradually dwindled over the years, the importance of human judgment at critical decision nodes has grown tremendously. Thus the engineer engaged in the management of materials and machines has to be increasingly concerned in future with the organization of suitable environment which will motivate the thinking man to play his proper role in the overall system.

MARKET RESEARCH

The value which Society places upon goods and services which contend for utilization of scarce resources, must be analysed for the engineer to provide those which are the most desired. The behavioural sciences and statistics work hand in hand in such analyses.

LAW

Engineers would need more than just a casual awareness of the Industrial, Commercial and Corporate Laws of the land which codify the prevailing socio-economic ethos of the community within which he operates.

CONCLUSION

A study of the interaction of engineering with the social sciences cannot merely be left to sociologists from outside. Engineers have to be directly involved in evolving guidelines for those who would enter the profession in the future.

INTERACTION BETWEEN ENGINEERING AND SOCIAL SCIENCES

S D Dave*

Aristotal said that man is a social animal. It is evident in man's reflection on society ever since the beginning of recorded thought, the reflection that it was not good for man to be alone. The life of man is many sided. There is an economic aspect, legal aspect, an asthetic aspect, religious aspect and so forth but blending into them all is the social aspect. In all else, he does, man relates himself to man. Society is the marvellously intricate and ever changing pattern of the totality of this relationship. Hence, the idea of society as a machine geared to the satisfaction of material needs only is a blasphemy entertained mostly by those who either by their culture or training treat them, not merely as basic but also as the highest in their scale of values. Economic planning does not occur in a socio-cultural vacuum.

With the fast changing society and technological advancement, the inter-dependance and inter-relation and interaction of basic sciences and social sciences is unavoidable. Perhaps, it is a must. Engineering deals with materials, manpower and finance. These factors involves knowledge of economics, sociology, psychology, law, geography, history etc. Engineering without social sciences is rather an impossibility. The basic sciences have got the value only due to their effective use for the welfare of the society. The basic sciences and their application which is termed as engineering, change the society as a whole with new ideas and new inventions coming everyday. An active concern for the vital health of the people of the world includes an active concern for the ways in which technical change is taking place. When the introduction of technical change is purposely initiated or promoted by individuals or responsible bodies such purposiveness involves responsibility for the effects not only in improved living conditions, but also upon the total way of life of the people for reintegration as well as a defence against dis-integration.

With this background, the importance of social sciences and their inter-action with the engineering are discussed in the paper.

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INTERACTION OF ENGINEERING & ECONOMICS

As mentioned above, engineering deals with material and finance, it is fundamentally necessary to know the basic principles of economics to prepare, execute and give the projects which are useful to the society at large. Knowledge of material management, effect of variable on cost of materials, substitution and supplementation of cheaper materials, demand and supply of the products, their effective use, etc is required to be known before taking up any engineering enterprize. Similarly, the use of availability and use of finance is also important.

INTERACTION OF ENGINEERING & HISTORY

Where special technical practices are to be introduced into a culture or a part of the society, which has hitherto used them, it is desirable to strip these technical practices of as many extreneous cultural accretions as possible. It is realised that the technologies and inventions of modern science are themselves the outgrowth of a very particular historically limited type of culture. History helps in designing the product as it gives the details of the use of old practices and invites to develop and improve the old one wherever necessary for much more use of the society.

INTERACTION OF ENGINEERING & LAW

Law is defined by the great jurists Rescopound as social engineering. According to him just as in the engineering law is also a result of interaction of forces having the conflicting interest and what is the price to be paid to provide stability in the society. In all engineering projects with the present day requirements of different rules and regulations, such as safety, fire protection, labour laws, contractorial obligations etc. it is necessary to have some knowledge of law.

INTERACTION OF ENGINEERING AND PSYCHOLOGY AND SOCIOLOGY

The manpower management requires demanding qualities of good managers and a good manager can be one who knows the mind of the people working under him, may it be, labourer, clerk, or a technician. The knowledge of these sciences will help him in behavioural attitude with the juniors and seniors and to establish good relations amongst the employers and employees.

INTERACTION OF ENGINEERING & LANGUAGES

As is quite welknown that the engineers can execute very big projects but are mostly failing in presentation of the works they have done and also in framing up the rules and regulations due to the inadequate knowledge of languages. This results into number of conflicts and put them in a very embrassing situation. This is particularly more so when they have to work with the politicians and bureaucrats who are expert in these fields and try to exploit the short comings of the engineering executive.

INTERACTION OF ENGINEERING & STATISTICS

No engineering project would be formulated without the help of statistics. As the projects have to be prepared for present keeping in mind future requirements the future projections can be made only with the help of past and present data involving lot of statistics.

Having seen the importance of engineering for the society and the importance of social sciences for successful engineering adventure, we can conclude that in the present day society, the knowledge of social sciences is a must for an engineer to enable him to do right type of planning, quick execution and to deliver the fruits of the projects to the society for the benefit of the members of the society. This will not only help the present day society, but will help the future generation also to reap the fruits of the technological advances that are taking place at a very very fast rate.

HYDROLOGIST AND SOCIAL SCIENTIST: COLLABORATION AVENUES

G Krishnaswamy*

Practicing social scientists should assess methods, models, instruments and yields from social research for their utility to scientists in other fields, as interdisciplinary collaboration, especially between social scientists and hydrologists requires it. Engineers should recognize that social sciences, when compared with other sciences are at a lower stage of development and economists and psychologists are at a higher stage of development than other social scientists. A great deal of this underdevelopment is due to the nature of much of the social science data and to a failure to fashion sophisticated tools for managing and analysing data. With some assistance from other disciplines, imaginative social scientists can develop means, mathematical or otherwise, for determining the extent and type of change two or more variables induce in each other at the same moment or along a chain.

Whereas engineers and physical scientists are trained indisciplines having a broad base of information and theory that builds block by block wherein each block is interdependent with other blocks, such conditions hardly exist in social sciences. This deficiency apparently makes it difficult for social scientists and engineers to communicate with each other. Further, there is always heavy pressure on social scientists from engineers to provide prescriptions for future action. A good deal of the efforts of social scientist will be based on impressionistic, unsystematic and common sense methods and theory which will be descriptive rather than explanatory. Much is to be gained by everyone through interdisciplinary efforts and even more can be gained if the engineers appreciate the problems and orientations of their collaborators. With the mechanical and electronic facilities available, discoveries can be forthcoming if the imaginative will acquire skills and apply them.

Until now, byfar, the greatest efforts to collaborate have been between engineers and economists. Members of the two fields have a fuller understanding of what each other attempts to do.

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Of considerable importance for future collaboration is the growing number of social scientists who are attempting systems approaches to the social sciences. Efforts in this direction have already begun to make the social sciences more cumulative and open greater possibilities for collaboration between social discipline and harder sciences. Special heed should be paid to the rapidly leveloping fields of communications theory and cybernetics. By finding out how people communicate with one another, engineers can determine some of the reasons why good programmes get shot down in the decision making arena. Another developing theoretical area is organisational theory. Still another area producing many reliable and valid yields is field theory which is really perceptual psychology using human perceptions as a basis for developing predictive and explanatory theory, the latter of which is really more descriptive than explanatory. Perhaps, the most fascinating but difficult area in which to assess yields is decision-making. A good deal of attention has been devoted to game theory and simulation. Of all the areas for potential collaboration between engineering and social research none stand in sharper relief than simulation. Simulating actual social relationships enables us to measure and test scientifically without disturbing the social milieu. Simulation does not require one to wait till the events transpire. Given the huge capacity of present equipment, one can order masses of data, feed the machine and jiggle one variable after another to see the difference it makes in others if any, when one jiggles certain items. Successful simulation will require engineers to think and work more in terms of stochastic models than parametric ones, since social researchers are forced to work largely without knowing the parameters to their systems. Engineers who collaborate with social researchers should be aware of a great many diverse pockets of development upon which they can draw usefully.

One of the developing areas right now that appears to hold a good of promise, especially in political science and social psychology, is communications and cybernetics. The impact of this science of communication on the social sciences has been more profound than a cursory reading of the literature in the field would indicate. In many cases, the impacts have been indirect and transmuted. Direct influences however appear in those social science research efforts which employ input-output models that stress the interactions of the political system with its environment. Concepts such as 'channel', 'network', 'feedback' and 'communications net' are becoming popular with political scientists. The models, operations and instrumentation employed by social researcher closely approximate many of the systems models used by engineering researchers. Communications research, thus, provides a common ground of understanding between social scientist and engineer. Further the engineer will be able to employ communications models to estimate and predict more fully what will become of his programme in the decision making arenas.

Regarding viable research enterprises on which collaboration should be sought, the following may be thought of. Intensive research is needed 1) on the ways in which public attitudes and ideological formations affect engineering outcomes, 2) on the ways in which engineering outcomes feed back to the social system to affect social change, 3) to develop valid and reliable scales and attitudes, 4) to obtain man-land relationships, 5) to test the ways in which model water institutions function under model water laws, 6) to seek to develop model water laws, model water institutions, zoning criteria and a host of other necessary features, 7) to develop criteria for zoning which seeks to maintain safety and aesthetic values and 8) to know about human coalitions. Of critical importance to engineers are decision-making procedures.

The key to successful research collaboration lies in the efforts experied to put the questions in a systematic and researchable model to which engineering designs and models can be related. Doing this will require engineers to relate themselves and their skills to the efforts and skills of social scientists. Team research on a highly organised basis is needed. All are to carry out research in their assigned portion and the yields of each portion should be relateable successfully to the yields in other portions of the design.

ORGANIZATION OF LABORATORY INSTRUCTION IN ENGINEERING EDUCATION

Dr G K Dubey*

Laboratory instruction is an important and integral part of engineering education. Technology has been developing at a fast pace. A large number of new fields and concepts have been developed in the last few years, requiring development and introduction of large number of courses and associated laboratories. However, large number of institutions and universities still continue to operate with old curriculam. If some have introduced the new courses, they have not been able to develop associated laboratories. Lack of funds has remained the biggest hurdle. Further, no thought has been given to look at laboratory programme as an integral part and to formulate the objects of laboratory instruction and to achieve them with minimum number of experiments and therefore with minimum expenditure.

In the last few years, the number of courses a student is required to take has increased. In many institutions growing need for the introduction of new courses have been met by reduction of laboratory hours. This has made it necessary to carefully plan the laboratory instructions so that the objects are achieved with the minimum number of laboratory hours and with the minimum expenditure of time. The success of laboratory instruction does not depend on the number of experiments which are performed or the equipment used, but depends on proper planning, organization and implementation. A few experiments of a well organized course may teach much more, with minimum equipment, than a large number of experiments of an unsystematic course.

In 2000 AD, a large number of new courses will have to be introduced and the number of courses which will become obsolete and irrelevant will always be less than the number of new courses that will be introduced. With the introduction of new courses new laboratories will have to be developed and new experiments will have to be planned, within the time presently available (if not less) for laboratory instruction. Situation regarding funds will continue to be difficult even if we assume considerable progress of the nation technically and financially. It will therefore be necessary to optimize the utilization of limited hours available for laboratory instruction on one hand and to minimize the expenditure on the other. To achieve this educational goals of the laboratory instruction have to be formulated and ideas develcped about systematic planning and organization of laboratory instruction, so that the requirements of engineering education in 2000 AD will be adequately met.

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This paper describes the objectives and presents an outline of the planning and organization of the laboratory instruction at undergraduate level. The ideas presented can be utilized for evolving an organization of laboratory instruction which will be able to cater to the needs after 2000 AD.

AIMS OF LABORATORY INSTRUCTION

The scope of laboratory education is to fulfil the following objectives:

(i) It should corroborate class room teaching to verify experimentally various theoretical deductions and to illustrate the application of basic principles.

(ii) From the laboratory courses, the student is supposed to acquire a knowledge of various test equipment, different components, usual measuring techniques, a few specialized testing and measuring techniques and concept of error evaluation.

(iii) It should develop in the student a certain mechanical aptitude, and a feeling for physical magnitude of the things.

(iv) A laboratory program should aim at developing in a student a clear understanding of the gap between ideal models and actual systems.

(v) It should develop in a student 'a feel' for a good technical judgement so as to obtain a balance between theoretical and experimental techniques of analysis and design.

(vi) It should provide training of planning and execution of experimental work and of interpreting the experimental results.

(vii) It should provide training in recording the experimental results clearly and writing clear and concise reports which can be read and easily understood by other engineers.

(viii) The laboratory course should give an opportunity to exercise engineering judgement.

PLANNING AND ORGANIZATION OF THE LABORATORY COURSES

The usefulness of the laboratory course should be judged on the basis of the above objectives and the course as a whole should be so planned and organized that all the objectives are attained.

It is the experience of many educationists that college students will do a bare minimum of work, unless they are interested. If they are interested, there is hardly any limit to the time and energy they will devote to a subject. The laboratory course, therefore, should be such as to produce in students a desire to work in the laboratory. It is the opinion of the author that any laboratory work which either fulfils the curiosity or provides the opportunity for independent work, motivates the student's interests.

The proposed organizational set-up consists of three stages. The student starts with the preset experiments in the first stage and is called upon to do more experimental work independently as he proceeds to the next stages.

Stage 1

Initially, an orientational talk is given to make the student familiar with the equipment, instruments, etc and to explain the procedure of recording and reporting the experimental data.

'Preset' experiments of short duration (about 2 hr) should be used in the beginning to give the student confidence and make him feel at ease. The instruction sheet is provided. This contains clear statement of the problem, and its origin and significance; list of apparatus, and brief description about their applications, limitations, accuracy, precautions for handling them, etc different steps to be followed and range in which measurements are to be taken with reasons for following these steps and taking the measurements in that particular range; conclusions to be drawn etc. If any discrepancy is to be expected between theoretical expectations and practical results, it should also be mentioned with reasons for its existence.

At this stage, the teacher has greater responsibility to train the students in recording and reporting the experimental data.

This type of experiment has the advantage that the student always knows what to do and therefore the results are usually consistent. Unsuccessful experiments, specially in the early stages, may create a feeling of disappointment which may jeopardise the student's interest in the experimental work. Another advantage is that the student develops good (through fixed) **work** habits.

Stage 2

This stage of the laboratory course intends to provide opportunity for doing the experimental work more independently. Here, the planning and execution of the experimental work is done by the student himself. However, if a number of alternative methods exist, the particular method to be followed is stated and its theory explained. The student is required to interpret the results independently.

A student finds this type of experiment interesting because of the fact that independent planning and execution of experimental work presents a challenge, gives an opportunity to apply knowledge gained in previous laboratory classes and theory classes, and calls for thinking and exercising greater responsibility. When a student completes the experiment, a feeling of success and achievement motivates his interest and desire to work in the laboratory.

State 3

The last stage of the laboratory instruction should be a project of one year duration and weightage equivalent to three courses. The idea behind the project is to give the student an experience in solving actual engineering problems and thus to give him an opportunity to exercise engineering judgement.

The student is given the specifications or the end results only. The specifications are often contradictory. The student has to decide which of the given specifications are more important, what additional data is to be collected and what his approach to achieve the required results should be.

He selects the components (or parts), collects the required data about the components, designs, constructs (or fabricates) the system (or equipment) on the basis of the design, devises the means and methods for testing the system, analyses the experimental results and finds out whether the specifications are met or not. If the specifications are not met, then on the basis of the test results (final results), he finds out if any component is to be changed or any modification is to be done in the design and construction of the system.

The student works on the project only once during his career in the institute/college. Because of the limited time, the project has to be simpler and smaller as compared to actual problems of the industry; however, it gives him a feeling of satisfaction and self confidence, and equips him with what is most importamt for an engineer, 'the engineering attitude'.

A proper co-ordination will be required between different courses so that the objectives are realized with minimum experiments and minimum expenditure. This will ensure accommodation of the requirements of all the courses within the limited time. If we want the situation of laboratory instructions to be good after 2000 AD, we must start working now itself on suitable organisation of laboratory instructions with the sole objective of achieving the aims of laboratory instructions with minimum number of experiments and minimum expenditure, thus catering for the requirements of all the courses within the time available for laboratory instructions and resources available for laboratory development.

REFERENCES

1. Report on engineering design-An interim report made on Nov 3, 1959 to the Dean of Engineering, M I T J Engng Education 51, 645 (1961).

2. PENNINGTON A G, A creative project course in electrical engineering Journal Engg Education 55, 247 (1965).

3. VAWEY W J, Undergraduate laboratories - some comments on efficient use of students time. IR E Trans Educ 2, 120 (1959).

4. SCHWARTZ R F Laboratory - it's scope and philosophy, I R E Trans Education 2, 120 (1959).

5. PLOTKIN S, A new approach to electrical laboratories, I.R E Trans Education 4, 9 (1961).

6. ERNEST E W and Kopplin J O, Modern objectives and methods for laboratory instructions. IR E Trans Educ 4, 168, (1961)

7. ALGER P L and WINSOR L P, A project laboratory for electrical engineering students. IR E Trans Educ 6, 9 (1963)

8. CHEREPIN V T, The diploma and course projecting. Report prepared for Indian Institute of Technology, Bombay.

9. DUBEY G K, 'Some ideas on Laboratory instruction in engineering education, Int J Electrical Engineering Education. Vol 5, p 215 (1967).

SHORT TERM COURSES FOR THE CONTINUING EDUCATION OF THE FUTURE ENGINEERS

D D Misra *

Short term courses in engineering are not new, but lately greater appreciation of their usefulness is being grown and in future these courses will play more significant roles in the continuing education of the engineers. Indian Institute of Technology which are themselves new, have been conducting such courses for more than a decade. Observations made in this paper are based on experience of organizing such courses in the Departments of Chemical Engineering and Mining Engineering at IIT, Kharagpur.

Representatives from the industry whose advice is sought from time to time in formulating the syllabi for the regular degree and diploma courses of the institute have been pointing out that though they would like some of their engineers to be educated further they are not able to spare them for a period of one or two years which is essential for a post graduate degree or diploma course. Short term courses which are now being organized on the request of such industries can be broadly classified into three categories.

1) Refresher Courses

These are mainly meant for refreshing the knowledge of the engineers in general, and to familiarise them with the new developments in their fields in particular. For example use of computers did not form the part of the curriculam of undergraduate courses in Chemical Engineering or Mining Engineering till a few years back; where as now these are included in the curricula. It is very desirable that engineers who have passed earlier should get an opportunity to learn the subject. Though they can learn it by self study, a short course specially designed for them considering their earlier educational back-ground can best serve the purpose. Needless to say that with the rapid developments in the different branches of engineering such revisions in curricula will be more frequent in the future. To keep the knowledge of the practicing engineers upto date in their respective fields short courses of two to four weeks duration would be eminently suitable.

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ii) Courses in Newly Emerging Disciplines

We are already observing the emergence of many new disciplines of engineering and in the future many such new disciplines are sure to emerge at a much faster and hitherto unexpected rate. Though it is expected that the educational institutions will start imparting education in these new fields in the form of regular degree or diploma courses, it is impossible for the new regular courses to completely fulfil the need for engineers trained in the new disciplines. The emergence of Mineral Technology or Mineral Engineering as a separate discipline in its own right is an example of this type. Though it has been so recognized for perhaps more than three decades and there have been atleast one institution in India giving specialized education in this discipline, the responsible positions in almost all mineral beneficiation plants are still manned by graduates in conventional branches of engineering like Mechanical, Metallurgy, Mining or Chemical Engineering or some times by Scientists specialized in Geology or Chemistry. The need for specialized training of the executives already employed in the mineral processing industry is best met by short courses of two to six weeks duration specially designed for their purpose. At IIT, Kharagpur we have observed that it is desirable to have one course in this particular branch atleast once during every summer as well winter vacation to completely fulfil the requests made by the industry. In future the demand for such courses for the newly emerging branches of engineering are bound to increase.

iii) Intensive Short Courses

These are meant mainly to give specialized training in a particular field. For example an engineer employed in a Mineral Crushing or Mineral Grinding Plant or with the manufactures of size reduction equipment would do well to attend a course which gives him specialized training in the art of size reduction. But a regular post graduate course in Mineral Engineering contains a lot more material which is hardly of interest to him. A short course specially designed for his requirement alone can adequately fulfil his needs. Needless to say that the need for such specialized training will increase many times in the future.

Apart from short duration which makes short courses more acceptable to the practicing engineers, these courses offer some more advantages like those enumerated below.

1. Non formal nature: This makes it acceptable to those engineers who are not willing to undergo the requirement of appearing at an examination at the end of the course.

2. Flexibility of admission requirement: Unlike the regular courses there need not be any rigid restriction on qualification requirements and particularly age limit. Thus these courses are open to a larger number of aspirants who would be otherwise deprived of continuing education.

3. Flexibility of syllabus: Syllabus for every short course can be different and revisions can be made much more easily than in case of regular degree or diploma courses.

4. Flexibility of venue: Though most short courses are held in the institute campus some are held in the premises of the sponsoring industries. This type of off-campus courses cannot be easily arranged for regular degree or diploma courses.

Because of their flexibility short courses can be much more useful for continuing education in a changing environment than the regular courses. Thus short courses have a much more important role to play in future and their importance should be recognized and proper arrangements should be made to fully exploit their usefulness. In one particular field their usefulness has not been exploited in India, ie, in educating the engineers about the know how and equipments developed in India. It has been observed by the author that manufacturers of process equipments in the western countries take a lot of trouble to educate the engineers in their country as well as abroad about their range of products. Representatives of manufacturers of mining and chemical equipments when visiting India often make it a point to visit the educational institutions like IIT to address the students about their products. Often they arrange short courses on their own and when notified about a short course they try to make use of the opportunity to introduce their products to the participants through lectures or distribution of brochures. No such effort by the Indian manufacturers to take advantage of the short courses in this manner has been observed.

It must be noted that in spite of the advantages they offer and the progressively more useful roles the short courses are likely to play those cannot be expected to completely substitute any of the regular degree or diploma courses of an educational institution. May be because of this reason at present no cost is incurred by the educational institutions for the short courses. Though in future it should continue to be so and the cost should continue to be borne by the sponsoring industries the educational institutions should spare some effort to co-ordinate and streamline the requests for short courses received from the industries. Industries on their part should try to foresee the training needs of their engineers and make the programme well in advance. Given proper planning well ahead of time the short term courses can play a very significant role in the continuing education of the engineers of the future.

GROUP STUDY METHOD

S D Tase*

INTRODUCTION

Some subjects of engineering disciplines need conceptual clarity, proper understanding and logical treatment of the subject matter to deal with solution of engineering problems. At present also, it is observed that the average student tries to tackle a problem, comes half-way along a solution and is stuck up. For some problems they do not know how to make even a 'start' for the solution of problem.

DIFFICULTIES IN STUDIES

(1) It is observed that many of these students will be able to 'Start' and to reach 'End' of the solution of a problem if they are given a 'small clue' or a 'hint' towards the solution. Now who is to give this clue to the student? With the ever-increasing number of students, it is difficult for the teacher to deal with 'all' difficulties of 'every' student.

(2) Students who find difficulties every now and then, feel ashamed to approach the teacher for the solution of the difficulty. When the difficulties are very large in number, (and which is true for most of the mediocre students), the student is not inclined to contact the teacher for such a help. Hence, his innumerable difficulties remain unsolved, which ultimately leads to failure in the understanding of the subject, as well as in final examination.

(3) In large Metropolitan areas, like city of Bombay, Calcutta, Madras, Delhi, the engineering student may not find enough time, after the daily institutional work is over, to study at the institute premises and contact the teacher because of very large distance between his residence and the institute and long time spent daily in travelling.

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GROUP STUDY METHOD

To overcome the above difficulties, the author has developed and experimented with Group Study Method at Shri Bhagubhai Mafatlal Polytechnic, Vile Parle (W), Bombay - 400 056. This method had proved to be extremely useful, especially in case of mediocre and average students.

(1) The author had assisted the students to form these study-groups.

(2) In a class of 60 students, about 7 to 8 groups of students were formed.

(3) Each group had one 'leader student' who was more clever as compared to other students of the group.

(4) The clever students were persuaded to be a leader of the group by the author. It was explained to them that their help to their fellow students will give them moral satisfaction of fulfilling social duties. Also this help was not to be of any kind of disadvantage to themselves. (It was later observed that such a help did not disturb the rank of the clever student in his own class).

(5) The student in any one group had residences relatively close to those of other members of the group.

(6) It was particularly observed that the students in any group should form a homogenous group so that no student should feel ashamed to ask difficulties to the leader of his group who had shown his sincere willingness to help his fellow students.

(7) Some times such a help to fellow students, in giving small hints for solution of a problem, did not consume even few minutes in a day for a clever student, but such a hint had helped the mediocre student and average student to obtain a solution of problem which posed difficulties to them. Such hints were given some time even when students of the group were discussing over a cup of tea in the Polytechnic Canteen.

RESULT OF THE GROUP STUDY METHOD

1) The effect of Group Study method was clearly seen in elevating the overall performance of all the students in a particular class, in the final examination.

2) It was observed that the students enjoyed a sort of pleasure in working with Group Study Method.

3) The clever students, who worked as leaders for their respective groups did express their satisfaction for the work. They enjoyed in guiding their fellow students.

NON-FORMAL EDUCATION IN NEW SPECIALIZATIONS

Dr O P Gupta*

The phenomenal advances made by technology has put before the engineers challenging demands for developing expertise in more specialized fields. Present day industry requires more of such specialist -- technologists than the generalist engineers. But unfortunately teaching institutes have not kept pace with this trend and at best, few such specializations are offered at post graduate level which often suffer from lack of practical bias. It is the far cry of today's industry and posts sometimes go abegging. **Moreover,** there are people in industry who did not have formal engineering education but who are in the profession for years. They are also, perhaps, in touch with the best facilities in the specialization and in general have better appreciation of the problems faced therein. A little bit of professional guidance and exposure to modern technological concepts will make them good technologists. This is the area where efforts should be concentrated, so as to quickly develop a cadre of mature professionals in order to satisfy the fast growing requirements of industry. The areas so identified (in production engineering discipline) are welding, foundry, tool design, process planning etc.

The Indian Institute of Welding has tried to give shape to this concept. A few innovations have been made. Because of the author's association with this venture from the very beginning, he plans to discuss these in this paper with a view to stimulate discussion on developing similar approaches in other disciplines. Basic features of the approach are short time exposures to academic environment and teaching by academicians as well as professionals at selected technical institutions, associated with a system of evaluation and award of certificates by the Indian Institute of Welding.

A survey of teaching trends in welding, both formal and in-formal, in different advanced countries of the world revealed widely different approaches. But the non-formal teaching of the shop-floor people and award of certificates has been recognized as an important feature of these.

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An unique aspect of the proposed approach is a three tier system of evaluation which recognizes the difference in mental capabilities of the participants. Few may be having greater desire for gaining a deep understanding of the subject while others may like to find simple answers to their routine problems or else may like to gain working knowledge of some elementary engineering subjects with which they may come across in their normal day-to-day working. The three stages of the system cater for the requirements of these different categories of people. The first stage consists of elementary engineering subjects, the second one elementary welding subjects and third one advanced welding and associated engineering subjects. A participant is expected to get a certificate after completing every stage and those are not able to cope with the first stage may drop out after first or second stage. But in passing these stages they would have definitely acquired some knowledge relevant to their profession which would have made them better suited for their employment and possibly for promotions. Making them more suitable for the job is definitely the aim of such education and it is author's conviction that the system will serve this purpose at least in the welding profession.

The paper also discusses some of the teaching aspects of such an adult education programme and points out to the difference in approach during preparation of subject matter for such courses vis-a-vis the conventional academic approach of teaching at university level.

REFLECTION ON MANAGEMENT OF TECHNICAL EDUCATION

Dr.P. G Rao*

Though this subject of management of technical education is not explicitly mentioned in the suggested subject break-up for the seminar, its importance is obvious. In fact, in a typical total systems approach, all other subjects become components or sub-systems.

There are academic problems and administrative problems in the management of technical education which require urgent attention. The estimates committee for parliament has made certain recommendations recently. It has said in particular that All-India Council of Technical Education has not been effective in overseeing the development of higher technical education and maintaining good standards. There is also a recent (Jan 1978) report of a working group on technical education of the Ministry of Education and Social Welfare of Government of India. It seems very appropriate that some of these problems are discussed in a wider assembly like the national seminar.

A few points are mentioned and briefly touched here. They will be expanded upon in the main paper.

1. Need for a unified agency for development of higher technical education in the country, a statutory agency like the U G C.

2. Manpower Planning: Manpower estimates can never be made accurately as they are functions of fuzzy economic parameters of growth and development. It is so even in more advanced countries. But the impact of inaccuracies in the estimates is more in a developing society like ours leading to either a shortage of trained technical manpower or unemployment of engineers. But there are other methods and means of coping with inherent and unavoidable uncertainties. One is a concept of adaptive control mechanism in controlling the admissions to engineering institutions at more frequent intervals. Admission capacities are more or less invariably for long periods of time as it obtains at present.

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3. Curriculum at first degree level: It can be argued that there is a need to reverse the trend towards introducing too much specialization at the first degree level at the expense of laying broad based and sound foundations of engineering science, design and practice. This tendency on the part of the engineering institution seems to have emanated from their trying to copy IITs, which is by and large, a differently designed curriculum. It is conveniently forgotten that IIT students are few in number; they are selected on the basis of an All-India entrance examination; and they are trained more for absorption in jobs in R & D establishments, sophisticated computerized design and analysis, and managerial responsibilities. The facilities and the environment in IITs also are different. The bulk of the students from engineering colleges go in for more or less routine jobs requiring skills of good practising engineer. There is need for a broad based curriculum with less emphasis on specialization. A sort of a multi-purposes engineer should be trained. They could go for specialization at the post graduate level.

4. The point made in the above can probably be formalized by having two different streams of engineers coming out with same feasibility for mobility in between. One curriculum is designed for producing engineering scientists and systems analysts and a second one for practising engineers who can design and construct the usual requirements of the practice and are good at it.

5. Interaction between engineering profession and technical education: Unless the profession is progressive in its outlook and approach, there cannot be high quality engineering education. There are many public sector organizations like State Public Works Departments and State Electricity Boards which seem to be happy with the knowledge available two or three decades back. They are too slow to change.

6. What is the influence exerted on technical education by the professional societies like the Institution of Engineers and the ISTE?

7. Interaction between the society and the technical education Admission procedures in various states - regional imbalance in availability of educational facilities - private engineering college charging capitation fees for admissions - why universities are not able to maintain standards?

8. Problems arising out of uncritical acceptance and introduction of semester system and internal evaluation in uncongenial environments and the undesirable consequences thereof.

9. Problems of training and retaining good faculty - different in the reward structure of the engineering profession and technical education.

EDUCATING THE ENGINEER OF FUTURE IN NEWLY EMERGING BRANCHES OF ENGINEERING

"WATER POLLUTION CONTROL"

V H Kulkarni*

PREAMBLE

Environmental Pollution is a newly emerging branch of Engineering as far as the Degree and Diploma courses in Civil Engineering are concerned. This mainly consists of Water Pollution, Air Pollution and Noise Pollution. In this paper water pollution control is discussed.

1. Introduction :

Water - Most essential commodity for human existance.

- Available in plenty in nature but all water is not in pure form.
- Costs money to purify.
- Scarcity of pure water.

2. Sources of water and their natural qualities in brief :

- Rain water.
- Surface water (stream, river, lake, estuary, sea).
- Ground water.

3. Uses of water :

- Domestic.
- Commercial.
- Industrial.

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- Public.
- Swimming.
- Recreation (Beaches).
- Navigation.
- Irrigation.
- Power Generation.
- Fishing.

Water is said to be polluted, when it is rendered unsuitable due to impurities in it, as far as its intended use is concerned.

Pollution of a body of water is the introduction into it of substances of such character and in such quantity that its natural quality is so altered as to impair its usefulness or render it offensive to the sense of sight, taste or smell.

4. Pollutants of Water :

1) Domestic sewage.
2) Industrial effluent.
3) Refuse dumping grounds - leaching action.
4) Insecticides, Herbicides & Pesticides.
5) Oil.
6) Toxic materials.
7) Trace elements and heavy metals.
8) Poisonous matter - Arsenic, cyanide.
9) Radio-active wastes

5. Other governing factors :

   a) Quantity of water supplied per capita.

   b) Volume and type of receiving water body and its use or not, as a source of water.

   c) Climatic conditions :

      - Rainfall (seasonal or otherwise).

      - Temperature.

      - Wind directions.

      - Sea currents.

   d) Country is developed or under-developed.

6. Main causes of pollution in developed and undeveloped countries :

   - In developed countries :
     More pollution due to industries.

   - In under-developed or developing countries -
     More pollution due to domestic sewage.

7. How impact of pollution was not felt previously and it is felt now?

   - Urbanization (Concentration of population : growth of population).

   - Industrialisation.

   - Concentration of sewage (shortage of water and hence per capita less rate of supply).

   - Collection of sewage & industrial effluent and disposal at a few locations (outfalls).

   - Less volume of receiving body of water for dilution.

   - Crossing the limits of self-purifying capacity of receiving body of water.

8. Effects of pollution :

   - Unsightly river banks and sea shores, beaches (sludge banks, coloured discharge).
   - Foul smell (Hydrogen sulphide, Methane).
   - Recreation value, swimming, bathing affected.
   - Fisheries affected.
   - Effects on Agriculture, Vegetation (ultimately affecting human health).
   - Cost of water treatment goes up.

9. Measures taken in Developed Countries to combat Water Pollution

   - U K (1876 Act).
   - Switzerland (Special problems)
   - Netherlands (Special problems)
   - U S

10. Measures taken in our country

    - Maharashtra - the pioneer State in the country to enact 'Maharashtra Prevention of Water Pollution Act, 1969'.
    - Government of India also enacted 'Central Water (Prevention and Control of Pollution) Act 1974, which has been adopted by 14 States other than Maharashtra.

11. General review of the present situation in our country for introducing water pollution control measures

    - Reasons for introduction of the above enactments :
      - i) Rapid industrial growth in urban areas.
      - ii) Domestic or Municipal sewage discharged untreated or partly treated.
    - Low priority to sewage treatment [illegible]

15. Classification of Water Bodies.

16. Monitoring for control : An urgent need

17. Inter-related subjects :

    1) Solid waste disposal for land filling.

       - Leaching action responsible for addition to water pollution problem.

    2) Action taken to control air pollution problem-- Scrubbing of smoke and such other industrial exhaust -- Creating water pollution problem.

18. Water Hyacinth (A plant growing in waste water):

    A positive pollution remover of trace elements as well - Unsuitable in our country as it creates mosquito problems.

19. Land disposal of partly or fully treated sewage and its special problems

    - Possible pollution of underground water.

RURAL ENGINEERING

J G Dahigaonkar*

THE AVAILABLE

Presently the rural development is conducted through Zilla Parishads and engineers manning these positions, are trained in the traditional disciplines, with a very different bias. They had to identify needs and approaches, necessary for rural development, by the hard way of experience. Many of them could not withstand the environment prevailing in rural areas and the small sizes of units to be constructed, with rather low specifications, made them sick. This continues to result in temporariness feeling, slip-shod, half-hazard approach and methods, wasting resources, time, money and energy. Attempts were made in past, to give both the general and technical education with proper bias, in 1949 by Radhakrishan Commission(1) and in 1954 by Shrimali Commission(2) and a few Rural Institutes (about 14 in the entire country) were started, and are working but these are very small in number to meet the demands, besides lot of other shortcomings.

THE RURAL DEVELOPMENT

The comprehensive rural development(3) implies improvement in living standards, equal distribution of rural income, economic opportunity and accelerated pace of development. This is dependant on 3 components - Technological, organizational and cultural. The technological development can be based on (1) Investigation of resources, beneficiaries; and decisions about proper technology, institutions and allocation (2) Identification of viable units (3) Infrastructure - housing, communication, sanitation, electrification etc (4) Institutions:- social, political, administrative, educational, financial (5) Industry. The present (aproximate) position and projected need (estimated) of the four basic components of infrastructure is given below, just to give an idea of task ahead.

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TABLE 1 POSITION AND PROJECT NEED

Component	Standard	Position	Projected need in next 20 years	
		% Population Served	Quantity	Amount (Million Rs)
1 Housing	House 40 m^2 + Cattle Shed + Courtyard; Low Specifications; 25-30 yr life; @ 5000/- each	40%	3 lakh houses 30%	150, 000
2 Water Supply	Safe, in Viscinity, through wells, canals	20%	300 Million	10, 000
3 Sanitation	Safe disposal of excreta - Trench Latrines Manure pits, Gobargas, etc	2%	300 Million People	10, 000
4 Roads	Fair Weather, WBMR + Culverts, bringing every village within 3 km of road	40%	9 lakh Km	270, 000

THE REQUIRED

The rural engineers' task, at different levels, will be to conceive, plan, organise and supervise (a) traditional and (b) newly developed activities. The traditional activities include construction of low cost houses, roads and culverts, village planning, water supply with bare essential purification, small irrigation works, rural electrification, repairs and upkeep of farm equipment, etc. The newly developed activities include installation and maintenance of Gobar gas plants, solar domestic units, chilling plants, etc. The engineers will have to be trained in conceiving and commissioning small isolated units (micro/approach) as against the large and comprehensive units (macro- approach) that are being developed or planned presently.

THE BASIS

The basic axioms of the proposed discipline are briefly as below :

1 Training youths drawn from rural areas, near their homes, in their language; with a explicit and clear understanding that they will have to spend their entire life in village environment and development.

2 Employment need to be assessed and admissions every year regulated to avoid unemployment and subsequent frustration.

3 Broader basis of education, in addition to the specialization.

4 Emphasis on optimum use of local resources; small units; gradual introduction of new technologies or techniques (to avoid social disturbances); cheaper methods and provisions, even if these may be uneconomical.

5 Chances of continuing education till his potentialities have been fully developed(4).

6 Preparation and production suitable instructional aids like vernacular text books, work charts, film stripes, etc.

RURAL ENGINEERING

The proposed discipline will be grouped into 2 branches: Rural Engineering (Civil) (= REC) and Rural Engineering (Mechanical) (= REM). There will be 3 levels of training in each group, according to performance need and nature of job. These levels will be : Certificate (technician), Diploma (lower supervisor) and Bachelor's Degree (higher supervisor, administrator, designer). Details of courses etc are given in Table 2 for RCE as an example. Initially, the faculty will have to be drawn from existing engineering teachers to be subsequently replaced by experienced rural engineers. Incentives will be assured jobs, free chances for improvement of qualifications, time scale promotions, change of line (upto 2 lower levels) etc. Finances may be drawn from rural development fund allocations on respective heads of infrastructure. Administration may be through existing directorates of technical education or separate units may be created. The ratio of persons at different levels may be assumed at the beginning as Certificate : Diploma : Degree :: 6 : 3 : 1, and should be modified later to meet demands. As a wild guess, rural engineering courses may continue for next 50 years.

ACKNOWLEDGEMENT

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REFERENCES

1 The University Education Commission, 1948-49 - Report - v 1, pp 554-590, Government of India Publications, New Delhi.

2 Rawat, P L. 'History of Indian Education'. pp 487-489, Publisher = Ram Prasad & Sons, Agra, 1965.

3 Joseph, S C. 'A Strategy to Eradicate Rural Poverty'. Yojana, (Periodical), v XXII, n 9, 16th May 1978, Yojana Bhavan, New Delhi, (inside front cover).

4 Technical Teachers Training Institute, Calcutta 20, 'Towards Newer Concepts and Methods of Technical Education in India' (A brochure), April 1969.

TABLE 2 DETAILS OF COURSE LEVELS ETC FOR RURAL ENGINEERING (CIVIL)

Name of Level (1)	Nature Performance (2)	Duration Medium (3)	Admission Standard (4)	COURSE CONTENTS (%) General Science (5)	Tech - Common Subjects (6)	Tech - Specialization (7)	Position in Employment (8)	CONTINUING EDUCATION FOR Passouts can join (9)	Dropouts can join (10)	INSTITUTIONS (11)
CRE(c) Certificate in Rural Engg Civil	Simple Repeatitive Routine work by hand Elem Accounting	2 Yrs Vernacular	8th std pass	50% covering full syllabus of 9th std in 2 yrs	20% Measurements, Drawings, Stores, Accounts	30% Any 3 trades* In each 25% theory & 75% practicals	Junior Technician, Mistry, Timekeeper, Head Artisan, Suboverseer	DRE after one yr experience	10th Std	I T I type at Taluka places
DRE(c) Diploma in Rural Engg Civil	Compound Cognitive Adoptive:- labour management Accounting	3 Yrs Vernacular + more use of English	Preference to CREs with one yr experience; Vacancies to 10th std pass	40% covering full syllabus of 11 & 12th std in 3 yrs	20% Surveying, Estimating, Drawing, Accounts	40% Bldg Construction, Irrigation, Water supply, PHE, RCC, Steel Project 50% Th + 50% Pr	Junior Engrs, Supervisors, Foreman, Draftsman, Estimator, Surveyor	BRE after one yr experience	appear to 12th std exam	Polytechnics at District places
BRE(c) Bachelor in Rural Engg Civil (Degree)	Complex, Cognitive, Multidimensional Creative:- Conceive, plan, design	3 Yrs English	Only DREs with 1 yr experience	20% covering subjects of B E (Civil)	20%	60% Advance courses in subjects above 70% Th + 30% Pr	Assistant Engineers, Sub-Divisional Officers, Design Assistants	Post-graduation in civil discipline	X	Rural Engg Colleges, one per 3 to 6 districts

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* trades like Draftsman, surveyor, canal supervisor, stone mason, brick layor, carpentor, plumber, concrete mason, steel cutter; Arch-layor, Gobar gas plant operator, etc.

Abbreviations : Std = Standard; Yrs = Years; Th = Theory; Pr = Practicals; PHE = Public Health Engg; ITI = Industrial Training Institute.

CONTINUING EDUCATION FOR ENGINEERS FOR THE FUTURE

S K Roy*

INTRODUCTION

Nothing perhaps is more important today for engineers of the future than continuing education. It is obvious that education is a continuous process. With tremendous growth of science and technology, a first degree at the age of 20 may not suffice for equipping an engineer for facing the challenges throughout his whole career. This is particularly true in the case of engineering profession where the continuous process is acquiring knowledge and then applying it in practice. But the whole process of application involves a large number of people and decision is usually made at a higher level. It is often found that younger people with modern ideas and developmental bias find it extremely difficult to pursuade people at the top to accept new methods, techniques and ideas. The remedy lies in continuing education so that engineers do not get bogged with ideas acquired at their old college days. Without continuing education, it is rather difficult to transfer modern technology or results of research from laboratories to actual field. Continuing education is in-expensive, less time consuming and highly rewarding and result oriented if properly planned and developed.

CONCEPTS

What are the essential concepts of continuing education for engineers.

1 The underlying idea of continuing education is to bring knowledge which is acquired or stored at the University and the engineering community who are supposed to apply knowledge together. If a still broader view is taken it is to bring the engineering institutions and the community together.

2 The scope of continuing education is indeed vast and varied. It will deal with the whole aspect of engineering profession, its needs and problems. Three broad elements run through the concept of continuing education:

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I Learning is a life long process.

II Acquisition of knowledge is in individual as well as social interest. For transferring technology, it is essential that people in decision making processes are made aware and participate in modern technology.

III The technical institutions with its store of knowledge, intellectual equipment and community of scholars is the most appropriate agency to do so.

3 The involvement of the engineering institutions in the service of the community is useful not only to the community but to the technical institutions themselves as this would make teaching and research in the institution more relevent to social needs.

4 The technical institutions should participate only in those tasks which it can do better than other institutions and in which it has a comparative advantage.

HOW TO ORGANIZE CONTINUING EDUCATION

To be useful continuing education must be properly planned and designed. Since it is proposed to reach senior people who are extremely busy and utility oriented, it is essential that the courses are so well planned and designed that participants find interest in them and find the courses stimulating.

Before selecting a continuing education programme the following questions may be asked.

1 Will the service meet a particular demand by a sizeable number of people and can this demand be demonstrated?

2 Will the educational experience contribute to the economic or technological upliftment of the people?

3 Do the participants care enough about the activity to support it with intellectual effort as well as fees?

4 Is the subject matter of the course on a level which most of the people will understand?

5 Is any other agency in a position to provide the service as well as the technical institution?

6 Should collaboration with some other organization be made?

NEED FOR AN OPINION SURVEY

It is proposed to undertake an opinion survey of the **practising** engineers on continuing education programmes now being followed in this country, the results of which will be embodied in the final paper.

REFERENCES

1 Report of Regional Conference of Continuing Education. UGC 1976.

2 Recent Advances in the Engineering Sources - Their Impact on Engineering Education. Mc-Graw Hill Book Co, 1957.

QUALITY AND RELIABILITY: A NEWLY EMERGING 'DISCIPLINE' OF TECHNOLOGY

S N Agrawal*

Prof R Saran*

A K Yadav*

Present day gigantic and sophisticated industries are networks of structural, mechanical, electrical and Electronics systems, each of these comprising hundreds and thousands of components. To predict the reliability of such systems and the risk involved in operating these industries, it has become highly desirable to establish a group, called 'Reliability-Group' in every industrial organization. The Group will have to maintain close surveillance over reliability oriented activities of the various departments and it should be in a position to report to the management for timely and appropriate action. Also from now until the turn of the 21st century, there will be tremendous strides throughout the world in enlarging and strengthening generation and transmission capabilities and improving system security and reliability and a massive commitment towards higher system overall efficiencies, and fuel conservation. So today and for the days to come the technology without reliability is unthinkable. But quality is the basis of good reliability and reliability can not be achieved without quality. The parameters, Quality and Reliability are unseparable and are of utmost importance particularly in systems for 'space' and 'defence'. During production quality and Reliability is to be maintained throughout by sustained motivation, inspection at crucial stages and a good balance between quantum of production and Quality Assurance.

As the Technical Education is primarily governed by the needs of time and the industry, and human is the most important of all the controlling factors, because he is the one who devices all the other factors, the Technical Institutions have to meet the challenge posed by the present systems and industry, by making available the properly trained personnels in this vital field of quality and reliability, whose everincreasing demand is an established

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fact. Though incepted after the first world war and further persued in the second world war by Germans and rapidly expanded and nurtured during sixties, at present Reliability Technology has got well defined and established techniques and methodology, and so is the Quality Engineering.

Now it is the responsibility and ethical duty of Technical and Research Institutions to develop and incorporate in their curriculum the study of quality and reliability in a phased manner. In view of this, in the first phase a subject on Quality and Reliability be introduced for the major branches of Engineering at undergraduate level and preferably a compulsory subject in Final year. Here the students should be exposed the basic concepts of Quality and Reliability, required to every industrial engineer and also to an enthusiast who wants to persue his studies further in this direction. This was one of the recommendations made in a seminar-workshop held at University of Roorkee during January 1978 to discuss and draft 'Syllabus of quality and reliability for undergraduate classes of Engineering', sponsored by Deptt of Science and Technology and co-ordinated by Dr K B Misra of Reliability Research Group, in which one of the authors of this paper participated on invitation. It was realized in this seminar that a Post-Graduate course is also a need which could be taken in second phase. An attempt has been made in this paper to emphasize the roll to be played by the Technical Institutions for the noble task of Reliability, which in the opinion of the authors is shaping as a newly emerging discipline of Engineering, and to present a draft syllabus for Masters degree in Quality and Reliability Engineering. The salient features of the syllabus and scheme are as follows:-

As usual, it should be a four semester course. The first semester breakup of the subjects be; Computer programming and Numerical Analysis, System Engineering I, Random Variables and Statistics, Reliability Technology. Each of 1 unit and Laboratory of ½ unit.

The second semester should consist of : Optimization Techniques; Quality Control Engineering; System Reliability and Quality and Reliability Evaluation Techniques each of I unit and the Laboratory of 1 unit.

The third semester should consist of: Advanced Quality and Reliability and two groups of Electives having the choice to select any two from the following courses:

Advanced Techniques in Failure System Analysis, Nuclear System reliability and risk assessment; Nuclear Quality Assurance Engineering; Quality Programme: Preparation and Audit, Fault-Tree Analysis; Design Statistics for Reliability Maintainability Availability and Quality Control; Human Reliability Prediction Applied to Man-Machine-System (under development). A Practical case study, seminar delivery and project will be part of this semester.

The fourth semester: Dissertation work preferably industry oriented.

TECHNICAL EDUCATION FOR INDUSTRIAL CAREER

V N Maller*

T Gangopadhyay*

Our present system of technical education does not seem to meet the requirements of the engineering man - power for industry. This is mainly because there is a greater emphasis on imparting training in basic theory rather than in engineering practice through courses in materials, engineering economics, business procedures, industrial management, engineering design or professional communication.

AREAS TO BE EXPLORED

Industrial engineers, especially working in the area of Research and Development, are expected to be creative, but our present day technical education system, which is mainly based on the requirements to learn facts, discourages the use of imagination of students. This situation can be corrected to a certain extent by introducing courses on creative thinking and creative design.

Engineering design is another field which is very much neglected under the present system of education. It is a decision making process, often iterative, in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a definite objective. It is necessary to promote more suitable methods, of both education and of design practice in the field of engineering design.

The tremendous growth in technical research has resulted in corresponding increase in the literature in these fields. However, our fresh engineers, especially of graduate levels, are generally ignorant of the present information system on literature available to them. An informal course on this subject may be introduced so that the students can attend this course for the sake of knowledge rather than for the purpose of credentials.

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Professional communication and technical writing are the other two fields which require special mention. Engineers in Industry cannot solve technical problems satisfactorily unless they develop the ability to communicate ideas both orally and in writing. Development of these talents must be included in the present engineering educational system.

Presently, the topics for academic research and project work of the post-graduate level are generally selected either on the basis of facilities available in the institutions, or on the likings of the concerned staff members. Very often they have more academic importance than practical significance. It will be worthwhile to select topics of practical applications appropriate to the prevailing technology instead of selecting topics of merely scholarly values.

TECHNIQUES OF TRAINING

In view of these various draw backs, discussed in the earlier section, with our present system of education the present paper proposes a system to redesign the engineering practice in Industry. Some of the distinctive characteristics of the different phases of the proposed system are briefly discussed below.

Phase - 1

The main emphasis in the first phase is on acquainting the students with the general business environments and helping them to see industrial organization as a system with inter-related components. They receive information on company products, organizational set-up, company procedures, etc.

Phase - 2

The main emphasis in the second phase is on providing intensive knowledge of engineering and technical activities. The programme covers areas such as product development, design, manufacturing processes, assembly, testing, sales engineering, service, material handling, plant layout, tooling, worksstudy, inspection and quality control, repairs and maintenance and topics related to material technology. The methods used for training include lectures, case studies, group discussions on practical problems, problem - solving exercises, library assignments and demonstrations in workshops and laboratories.

Phase - 3

The emphasis in the third phase is on providing students with problem solving experience which is the focal point of the entire industrial training programme. Courses at this stage are given mainly through projects and job assignments. The students will have opportunities for selecting and defining problems, applying theoretical knowledge seeking services and information from others, exploring alternative possibilities for arriving at definite solutions, making constructive suggestions, working under certain pressures and limitations, developing written communication skills etc.

Phase - 4

The project work will be treated as the fourth phase of this system of education. The entire project programme, from the stage of selection of problem to finalization of the report will be carried out by the students under the direct supervision of faculty members, and the guidance of senior executives from the concerned industry.

Details of this course pattern in four phases and the way in which they can be implemented in our present system of education are discussed in the paper.

EXTENSION -- A NON-FORMAL APPROACH

Prof R G Janakiraman *

In the Pre-independence period the Engineering Education has been confined to one of maintenance, mostly and the demand for qualified engineers was met by a few institutions in the country.

After the independence many activities were expanded and the demand for engineers rose to a very high order and this naturally had to be met by increasing the opportunities. For educating the candidates in the art of engineering, by the start of many engineering Institutions. The Governments, with the help of private Philanthrophists, started many new institutions both at the degree level and the diploma level.

To start within the first few plans the emphasis was on (a) increasing the facilities (b) increasing the variety of courses,etc (c) increasing up to post-graduate levels, (d) improving the quality of education by improvement of facilities.

These naturally have taken time and the financial res resources.

Further improvements have to be done in the areas of (a) attaining self sufficiency, (b) inculcating the spirit of serving the rural industries, (c) consultancy services etc.

The author wishes to state that in these days when open University systems are being thought about, extension of University Education by the fully developed institutions can be thought about.

The Institutions which are capable of taking the responsibility of running a parallel institution in the same campus and are capable of finding resources for running them and students who can support their studies can be encouraged to start other institutions. This idea will crystallize and they may be permitted to award their own diplomas etc and the Universities may be there to scrutinize and approve their

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standards. This activity which is to be done in addition to their normal running of the Institution will result in many advantages, as follows :

(a) increasing the infrastructure without any cost either to the managements or the state or the Central Governments.

(b) Utilizing the staff members and their capabilities to a greater advantage. This can also result in financial benefits to the staff.

(c) increasing the use of the buildings and equipment.

(d) Providing greater opportunities for the society.

(e) This will tone up the discipline of the students in the normal University courses by making them compete with an equivalent or more numbers of engineers.

ENGINEERING COMMUNITY, A CATALYST FOR DEVELOPMENT OF INDIA IN TWENTYFIRST CENTURY

T N Misra

Engineers, Taylor, the father of Scientific Management[1] & Fayol, rather of Management[2] changed the destiny of the world by effective use of Technology & by perpetuating the Management thought. Likewise we hope the Engineering community shall again give lead to the world and meet the challenges of the 21st Century.

Indian Problems cannot be taken in isolation[3], yet they are, a proportionate high population rise as compared to the developed[4] world, with consequent, dependency on the later. Of a total of 329 million hectares of land[5], the cultivable being 164 million hectares, to increase the Irrigation, which is only 39087 thousand hectares and to increase mechanical farm power which is only .0001/HP/hectare[6]. This is necessary to produce the extra 100 million tonnes of food grain required by 2000 AD, by which time severe Government[7] controls are expected.

We have 2000 MT of Lignite, 24 MT of non-[8]coking coal and 1600 MT of coking coal & thus there is no shortage in the near future. On the Neuclear front although we have 22000 MT of U308, about 5 million TWH of energy lies in the sands of Kerala and Ranchi, which can be harnessed by fast breeding reactors on commercial scale using Thorium based process. Thus, here is a mighty challenge to Engineers and Scientists. Besides we have tapped only 12000 MW of countries Hydel Potential of 50000 MW and similarly there is an ample scope of Thermal Generation. We are slipping at the rate of 2000 MW per year[9].

Apart from the above fronts, gigantic engineering efforts are required to check floods, to provide transportation, checking soil erosions, river and atmospheric pollution and to develop new vistas like bio-engineering[10], aero-space radiation technology etc.

Now the question is are we equipped to meet this demand of the Society ? Well ! not by present measures. Although Indian Engineers have independently done the neuclear blast at Pokhran and have created Production Facilities for Electronics Corporation at Hyderabad, they lack energy, enterprise, professional pride and dedication[11]. A survey of 2000 Managers/Engineers[12] reveals that there are overtones of authoritarianism, fatalism, love of steady jobs, elitism, class consciousness and contradiction between form and content. Besides in the Engineers there is high technical obsolescence[13], unprofessional ethics and intra group conflicts.

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Thus a drastic set of new values have to be evolved. In a society which lacks professional[14] politicians and which bristles with traditionalism, casteism[15], provincialism, the transformation i going to be none the easy.

Yet, in Engineers a basic culture has to be inculcated so that they exert a pull in the right direction as the demands from the environment become dominant.

The basic start is to be made by the Universities, which accordingly to Drucker[16] , are most inefficient, as they do not exercise the influence they have on the society, nor they are aware of their dominant power.

With the fast change in technology and need for the knowledge, in fields such as Systems, Behavioural[17] Sciences, Industrial[18] Relations and Management Information[19], not only the number of years in the schooling shall go up but cycles of education,[2 shall increase backed by professional courses of continued education. As a social security we shall have to have Engineers with requisite 'Professional Expertise' of which definite ethical codes have to be evolved to guarantee that the licensing system shall ensure that the minimum standards are maintained.

REFERENCES

1. Koontz & O'Donnel. Principles of Management. McGraw Hill, p 15 & 17.

2. F W Taylor. The Principles of Scientific Management. Harper & Row, Japan, p 142

3. Buckminster Fuller. World of 2001 AD Ed Shyam Ratan Gupta. India A study in Futurism; Abhinav Publication, New Delhi

4. Douglas Ensminger. Food enough or starvation for Millions. Tata McGraw Hill, F.A.O 1977, p 204-205.

5. Indian Agriculture in Brief 15th ed. Directorate of Economics and Statistics Min of Ag p p 1-47-284.

6. Ensminger op. cit. p 455.

7. Paul A Samuelson. The State and the Market the changing relationship between business & Govt. American Management Review, Dec 1977, p. p 14-16.

Contd. 3/-

8. P D Henderson. India: The Energy Sector, A World Bank Publication, Oxford University Press Int Bank for Rec & Dev, USA, 1975 p. p 9 & 10.

9. H V Dayal. Economic Times, 17th June 1978.

10. 'Verma Committee Report". Administration and Engg set up of Hospitals Min of Health (G of I) 1973 p. p 8-9.

11. K C Khanna. Are Our Engineers Any Good. Illustrated Weekly of India, Vol XCVI, 38 Sept 21, 1975.

12. Ramachandran, Karunakaran, Venkateswaran. What Young Managers Think ? All India Management Association, 1976.

13. Kamla Chowdhry. The Generational Conflict in Management; Management of Conflict I.I.M., Ahmedabad, p 23.

14. Prakash Tandon. Professional Management in India: Its Potential and Problems, Deptt of Bus Adm. P.A.U Press, Ludhiana, p.p 12-13.

15. A D Moddie. Exploration in Management Development. IMA 1976, p 27

16. Peter F Drucker. The Age of Discontinuity. Pan Books, London P 249.

17. Hersey & Blanchard. Management of Organizational Behaviour, Utilizing Human Resource. Prentice Hall, New Delhi, 1972, p 1.

18. B Von Haller Gimler. Industrial Psychology. McGraw Hill, Tokyo, p 406.

19. Murdic & Ross. Information Systems for Modern Management. Prentice Hall, p 547.

20. Allan C Filley & Robert J House. Managerial Process & Organisational Behaviour. Scott Foresman & Co, p 492.

21. Michael J Hill. The Sociology of Public Administration. World University, 1972, p 162.

SOCIAL AND TECHNOLOGICAL SCENARIOS IN 2000 AD

L N Misra*

Till the 19th Century Man has gone along with nature and used nature for human well being in its natural form ever since man was born. The technological improvements of the present century have been so used that the resources of nature have been changed where necessary and controlled by man for his well being. The most important aspect of the Scenarios in 2000 AD will be that man would have controlled nature to such an extent that nature will function not as the master but in the service of man at man's command.

The above being the general position let us examine each aspect in some detail.

Since I am from Mining and Metallurgical engineering Division, I will examine technological aspects of this branch first. Future Steel Plants will have completely changed skyline. Blast Furnace, Coke ovens, Open Hearth, Stripper, Blooming mills and Billet mills will all have been replaced by a process where Iron ore and Coal will be fed at one end of a Rotary Kilnst and after a set of processes and passage through oxygen what will come out at the other end will be molten steel. Combined with continuous casting process, billets will be available straight for rolling. Metallurgy itself would have taken a shift. Iron ore will be replaced by lighter metals. Steel has a life of 30-50 years only. These lighter metals besides being lighter, last centuries.

And metals would themselves have been replaced by plastics. Organic Chemistry would have changed face of things. The dress, the houses, the day-to-day use items all will be in plastics and will make life colourful and gray.

Mines are on the way out. Why waste energy to bring anything on top and then use it for providing electricity or anything else. Some reactions can take place underground and finished product can come out like Gas even today.

There are deadly diseases today. By 2000 AD, there will be no disease for which man would not have found a medicine. But, then having cured all diseases man will think of prevention rather than cure. And then man will go to or shall I say go back to 'physical Culture' that is our 'Yoga'.

Surgery will be bloodless and of course painless. Super fine high frequency laser knives will pass over the body and the skill will be cut clear. Simultaneously, open tissue will get sealed and will not bleed. Then just as you paste two pieces of paper together, skin will be joined with a solution. No stitching or anything of that sort.

Our fields will have different looks. Fertilizer, pesticide Irrigation and even music will produce more and more food. But then man will turn to sea for sea foods as sea produces 20 times more food per unit area of land. Then also by controlling chromosomes quality and quantity of food would have been increased. Not only that even bring creatures would have been created.

Man will be the master and he would have controlled things so much that he would have changed the climate of Sahara, Rajasthan, Siberia and Alarka. Houses will be built at speeds unknown so far.

Electronics will be the brain of engineering controlling everything. Trips to moon and stars will be controlled by such units. Radio and telephone will be so common that man will not then imagine how only in the beginning of 20th Century we talked to people on phone without seeing them. Everything will be available by control as bed room button. Even schools will be brought home by Television so that fewer teachers teach more pupils.

The population growth would be the greatest phenomena and there will be bigger and bigger cities with more thickly populated Centres as the time Passes. Electricity itself could be replaced at any places by more abundant and cheaper sources like there will be no more electric lights each city and it will be so controlled that when God made sun goes down man made sun takes over charge and lights the cities.

Today calculations take time even with Calculators. They will be millions time faster. Not only that those who have a great deal of scientific knowledge will be helped by the memory of Electronics machines.

Transport will run at 200 mph by high frequency motors over sleeping conductors built in the roads without reciprocating oil engines. Also cars will be operated on simple command. Planes will fly 50/60 thousand ft high far above the weather at 5000/6000 mph. Just imagine - 'work upto lunch in Delhi then go to London and have breakfast the same day and after working there till lunch return to Delhi for dinner in your own house all in one day.

Radio astronomy will open a new world. Ordinary lenses will be replaced by Radio window through which we do not know what all we may see.

Once space is tackled, other stars like moon and mars will be our picnic spots. Then newer and newer metals will be available. Any why bring raw-materials. Reaction will be made to take place there and only finished goods will be brought to earth.

A question may worry some of us. Will man's mind become inactive when he achieves this. No. Universe is so big and man's life span so small that man's mind will get further avenues to explore.

In H G Wells picture, it is stated that man will have so much devastations and create so much Radio activity on surface that man may be living underground.

Thus, in any case, the basic point is that where man depended for its service and nature till 100 years ago, will in future depend on 'Manmade everything'. And that is what brings to the Engineer a very prominent role. Not only Engineer even the commonest citizen will have to know simple principles of engineering to be able to understand and use this. It is likely that Civil Engineering will remain the mother Engineering. Mechanical Engineering will do the bull-work. Electronics Engineering will be the brain and will control engineering. It is a huge problem how to train all our population in all branches of engineering in such a short time.

SHAPE OF ENGINEERING EDUCATION IN 2000 AD WITH REFERENCE TO EVOLUTION PROCESS OF SYSTEM ITSELF

Dr S Prasad*

There are two broad divisions of history. The first is the pre-independence period, which gives a sad picture when we compare ourselves with the other parts of the World during that period. It is rightly said that India did not have industrial revolution. In the name of engineering, Britishers wanted only those who could have been used as maintenance engineers. The second part is the post independence period. It is a fact that base left was most unfavourable to chalk out a meaningful programme. However, the need was felt to have design engineers so that the free India could develop their own expertise to launch various industrial programme to achieve self-dependence on socio-economic lines. Various committees were set and as a result IITs, Regional Engineering College came up. The three tier educational system comprising degree, diploma and trades were rehatched and modernized with the purpose to satisfy the existing need. But after 30 years of our independence, if we look back to our own plannings, the assessment gives a horrible picture. Why we have failed in producing right engineers for our country is a collective mistake. It is beyond doubt that the input given to an engineer during his studies is by any measure, comparable to any curriculum of the developed countries. But so far as our own society is concerned, they are not only in huge surplus but also to a large extent off the track, so far as the utilities are concerned. This leads to a common doubt, so far as our failure in any group activity is concerned. We have failed to be realistic in any planning and also there has been total lackness in co-ordination amongst various wings of the same profession and thereby a catestrophical condition has arisen. An engineer can be well suited in USA involved in the most sophisticated space research, but in his own country, he finds it hard to show and establish his worth. The wrong and disastrous tradition being followed by our society hardly leaves any hope for improvement. Hence until or unless, we are determined to change our social structure, nothing significant can be achieved even in 2000 AD.

However, the progress of time is inevitable and the impact of various developments has to affect the shape of our life. So even with some of our traditional handicaps, we have to think about the shape of engineering education which has naturally the most important role to place a country in the international map. It is essential to visualize the socio-economic conditions which may have a drastic change over what is existing today. Population explosion, morality level, energy potential, scientific achievements, etc may be totally out of tune. Based upon that and keeping a closed-loop system approach in view the proposals are as follows :

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(a) Routine engineering disciplines at diploma level to be conducted in institutions to which user industries are attached for their practice scheme.

(b) For degree and advance studies, new branches would emerge out, such as -

(i) Energy Engineering
(ii) Environmental Engineering
(iii) Space Engineering
(iv) Electronic Engineering
(v) Rural Engineering
(vi) Human Engineering

CONTINUOUS EDUCATION OF ENGINEERS IN FUTURE

N S P Chawla*
K K Ahuja**

Engineer is more akin to practice and engineering education need to be matched with the technical skill required in industries. Education on the other hand should develop faculties of the mind and the intellect of the students to prepare them to face the fast changing socio-economic environment.

As we are aware that education seems to be drifting towards crisis for not able to adjust to the needs of the society. Engineering education cannot be imparted in isolation. It should not be alienated from the actual educational process. A rational educational policy for engineers can only be in collaboration with the industry through the cooperation and coordination of educationist, employers and other professional bodies.

Engineering education should be broader based, so as to achieve its objective of imbibing creative thinking and problem solving among its students. Engineering education have been explained in our paper in 4 phases:

Input Phase dealing with the importance of basic and the initial information, strengthening the abilities of the students to structure their thoughts and to help them to identify their emotional and perceptual complex to creativity.

The second phase of education is to give the conceptual and the basic know-how to the engineer by various teaching methods.

The third phase, entrance to the user organization deals with the 'Orientation Training', 'On the Job' training, technical skill, human relation and conceptual skill.

The final phase, the Continuous Education of Engineers deals with updating their information through 'Off the Job' training, 'Job Rotation', 'Horizontal Training' which can be handled through systematic training and development programmes conducted in the Industrial Organizations.

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Due to fast changing technological advancement during the last 25 years, there is a need for quantum jump and drastic change in our engineering education. There is a need for re-training of our faculty members in order to reduce the gap between academic and industrial world.

The paper deals with the concept that education is a continuous process of learning and is more akin to develop personality, skills and attitudes of an individual. Engineering education should have social, institutional, industrial and above all self-development training. In social training, an engineer should be trained to work with and through the people. He should be trained to be at home in dealing with his family members, friends, colleagues, peers, subordinates and seniors. Institutional training should emphasise on building a strong technical base. It can be acquired by working on the job. Industry has a role to play in imparting latest information and techniques through systematic training and development, given time to time by various Inplant training programmes. Self development is an important aspect of education. Self - the biggest mystery of a man is the man himself. Every individual has 4 areas of Self.

Known to the individual only.
Known to individual and others.
Known to others only.
Unknown to both (Dark Area)

To develop, he should explore the latter two areas by appreciating his objective criticism and showing lot of initiative and enthusiasm for the unexplored areas.

Engineer should expose himself to more stimulus to acquire knowledge, positive attitude, a will to work hard as an individual and as a member of the group, in a changing environment, in and outside the industry. The training in the areas of human relation, industrial relation, group dynamics, organization development should also be imparted to engineer.

Engineering education should be meant to reduce the incapabilities between individual and social goals. Technological education is less complex and bears a direct relation with the object of developing skills, to handle material resources towards prosperity. Engineers need to have an insight among themselves and an appreciation of social dynamics to improve their own life, organization culture, society and the nation as a whole.

Change of contents of academic curriculam, training of faculty members, broader based education of engineers, collaboration of industry and academic organisations etc have also been discussed in this paper. Thus engineering education should create among its students a sense of duty, discipline, qualities of leadership and an integrated personality with a capacity to adjust to varying situation. All efforts should be made to provide an all round development of engineers, leading toward an integrated and dynamic personality. Thus, technical or engineering education should not overlook the elements of human values and feelings which is the crux of engineering education.

EDUCATING FUTURE ENGINEER

Suresh K Parikh*

Education of future engineer deserves special considerations mainly because of two aspects. Firstly, the education so far has not satisfactorily met with the needs of the customer in particular and of Society at large. Secondly, the technological advancement and the complexity of Society demands additional help from engineers.

Further, as more openings are available to technical personnels for working in the high up executive positions, to act as a member of the inquiry commissions, reporting feasibility of the projects to be undertaken, to interpret with full understanding the political interferences and to evaluate the proposals put up before them, all these need much more rigorous educative efforts apart from the usual curricular commitments. The change in the social trends would also mean special interpretations. The meaningful study of humanities - Social Sciences - as an integrated part of technical education will go a long way in developing right type of engineer capable of delivering goods as expected.

Thus the technical education should be first an 'education' and then 'technical'. So like any other field of higher education, the technical education should serve two main functions, viz, to

i) prepare the student for a job - a profession - and to this end he should be offered the related information, knowledge, technique and skill.

ii) place before the students the relevant aspects from humanities with a view to help him in building up a healthy development of his total personality.

For all these a much more integrated approach would be necessary. The student may be given a basic understanding regarding various political theories, essentials of world religions, technological development and its related problems, role of individual in human development, man's relation to the universe, history of scientific advancement and technological development, place of literature, art, music etc in the human development, etc. This may not be imparted in an formal informative manner but he should be made to realize that all these components go for a building up of good life, total human being which is much more essential than any vocational success. Any achievements of the future are to be evaluated not in terms of material rewards, profit or loss but in terms of human welfare. Man would be the measure of everything. Such a developed engineer for the future would be the mutations for the future evaluation and an arrival of a moral man which may be a dream of today but a reality of tomorrow.

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For a good amount of period, our institutes may not be in a position to appoint a special cadre for this. Some of the faculty members will have to undertake the responsibility. The students at the first year level may be exposed to potentiality and possibility of a fully civilized engineer. Their response may be closely observed and some of them may be picked up for developing them through co-curricular and extra curricular activities like study circles, debates, etc. And at the final year level some of them may be taken for a much more rigorous sincere development along these lines. A sufficient coverage will have to be achieved through the guest speakers from different faculty and other walks of life who are already well known for their own integrated development and active constructive contributions for the good of the society. Even the faculty members can be oriented through small duration's seminar and workshops to undertake such a responsibility.

Whatever additions and alterations that we carry out will not bring out the final expected results unless we change our attitude and approach in this direction, for example,

i) We should pay more attention in building the concept of the subject. Let us make the student understand the fundamental assumptions underlying the basic theory and its related formulae.

ii) The student should be recognized as an active and predominant partner working with his teacher in the persuit of knowledge. The teacher should try to explain him as to 'how to think' and not 'what to think'.

iii) Right type of students should be admitted and then trained in our technical institutes looking to the expectations and needs of our ever developing engineering activities.

iv) To improve our efforts in engineering education and to make it more meaningful, a closer cooperation should be established between the industrial professional firms and technical educational institutes.

v) The faculty members should be encouraged to take up the assignment with projects, design offices, etc at regular intervals. This will make his teaching more relevant and work-oriented.

Education processes neither should be thought to be restricted within the four walls of the institutes nor it should be limited to the students enrolled and nonformal education open university postal correspondance courses etc may be tried in different forms. Lenin started mass movement of polytechnisation and education institutes were connected - corelated with fields and factories. In China Mao had successfully made the education social and rural centred. Community colleges are increasing at the rate of about fifty per year in America. Shri Lanka emphasis a lot to make their educative services rural oriented. No society/nation can exactly transplant the system from the other country but ideas can be carried and translated into action that may suit to the conditions of one's own set-up. We have yet to do a lot in this direction so that our engineering faculty may train the youth for the rural development in terms of appropriate technology. A lot of efforts in field work and academic institutes are needed to make the engineering really oriented for intermediate technology that may be useful to our rural folks.

SESSION—8

NATIONAL SEMINAR
ON
EDUCATING THE ENGINEER OF THE FUTURE
BANGALORE, JANUARY 7-10, 1979

S-8

Keynote Address by Shri T N Subba Rao

Key Note Address by T N Subba Rao*

It is a great pleasure and privilege for me to be called upon to chair a session for this important national Seminar on 'Educating the Engineer of the Future', for which the participation of so many distinguished engineers, scientists, and academicians reads like a roll call of Honour! As the subject for this seminar is one that concerns the adoption of our subject to the needs and demands of tomorrow, may I take this opportunity to share some of my thoughts with you before I formally declare the session open.

In this session on 'Educational System', our attention should be focused on the prerequisites of an Educational System that would equip the future Engineers with the skills and attitudes required to meet the formidable challenges that lie ahead of them.

We are now increasingly aware of the truth that though the essence of technology may have universality of application and relevance to all societies, the structure and models of technology we have borrowed are adapted neither to our needs nor to our problems. Our investments in Education seem to have gone askew somewhere. The time has therefore come for us to take a fresh and objective look at our fundamental aspirations for technological papers.

What is the kind of educational system that will be relevant to meet the needs of the future? I would believe that an educational system which inculcates in the young the values of 'Scientific Humanism' would be an uncompromising imperative. It should be 'Humanistic' in the sense that it should be concerned with man and his welfare as the main and worthy end in itself; it should be 'Scientific' to the extent that its humanistic contents are defined and enriched by the continuing new contributions of science to the field of knowledge about man and the world.

Technology, as we know is a systematic application of organized knowledge, to practical, concrete tasks enabling man not only to gain a better understanding of the objective realities and processes of his environment, but above all, to enhance the effectiveness of all his activities. In view of this, it is essential that science and Technology should become everpresent complimentary elements of our educational enterprise.

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Our present educational system, unfortunately, relies excessively on theory and memory. It gives a privileged role to conventional, written and repetative expression and in the process kills the values of awareness, spontaneity and creativity.

Where then lies the motivation in our educational system? At present the only rationale of our educational system seems to lie in the elaborate orchestration of the degree-employment mechanism which our economy just cannot satisfy! It is time we dismantle this structure and evolve a pattern of modern democratic technical education which revives and motivates man's natural drive towards knowledge. The aim of education should be for man to 'be himself' and 'to become himself'.

What should be our strategy and the style for reorienting our educational system. In this context, I have a few observations.

1. While we are designing an educational system relevant to our society, we can have an elastic approach and draw ideas from the wealth of educational experience of other countries.

2. We should commit ourselves to the belief that every individual must be in a position to keep learning throughout his life and this lifelong education should be the basis for building a 'Learning Society'.

3. Educational institutions and means must be multiplied, made more accessible and must offer the individual a far more diversified choice.

4. Education should be dispensed and acquired through a multiplicity of means. The important thing should not be the course an individual has followed but what he has learnt and acquired.

5. Efforts must be made to bridge the gap between educational institutions and industry through a process of continuous manpower osmosis.

6. Conditions in which teachers are trained should be profoundly changed so that they become educators in the true sense instead of being specialists in transmitting pre-established curriculae.

7. Education should be made a function of the entire society and larger and larger sections of our population should be encouraged to take part in it.

With these sentiments, I conclude my introduction to this Session, which, I am afraid, has become longer than I intended it to be. I express my gratitude to you for giving me a patient hearing.

SESSION—9

NATIONAL SEMINAR
ON
EDUCATING THE ENGINEER OF THE FUTURE
BANGALORE, JANUARY 7-10, 1979

S-9

Address by Prof U R Rao

ADDRESS BY, PROF U R RAO, CHAIRMAN, PANEL DISCUSSION

The growth of science and technology and its impact on society during the last century has been phenomenal. The release of the energy from the atom, the remarkable growth in electronics and man's ability to work in an from outer space provide, for the first time, a new era of hope to all developing countries wishing to advance scientifically and technology, during the last century, has amply demonstrated, that it can, in fact, provide hope to the 70% of mankind living below the poverty line. As for example, a variety of energy sources including the option of nuclear energy is available today to meet the growing demands of mankind. Efforts are continuously going on to tap abundant sources of solar energy, wind, tidal and other forms of energy available in nature. The discoveries in the fields of medicine and genetics allow us to do the organ transplantation including heart transplantation. Rapid advances in agricultural technology have led to better seeds and fertilizers resulting in improved agricultural practices and increased production. Modern technology has taught us how to put tin on the can thinly, how to substitute scarce and expensive materials with cheaper and more abundant ones such as plastics and so on. Remote sensing of earth resources, accurate weather prediction and modification, global telecasting through satellites have already been accomplished with the advances made by space technology. The possibilities of tapping solar energy from space, space colonisation and even exploitation of mineral resources from other planets are no more dreams.

Through space exploration, for the first time, we have been able to oserve the universe in the entire electro-magnetic spectrum. It has been possible to gain a great deal of information on planetary atmospheres including our own through in situ measurements. Space technology has also provided the required impetus for the development of light weight materials including composites, microwave and optical communication equipments which are quite likely to revolutionise the industrial scene. With space transportation becoming cheaper through ahuttle and heavy lift launch vehicles, space manufacturing of materials and tapping solar energy from space and even space colonisation are round the corner. Thus the humanisation of space has opened up a totally new vision of our future society. It is possible that before the end of the century, man will be able to detect intelligent life elsewhere in the universe. Looking back at the history of earth, essentially 800 life spans can cover the growth of civilisation of which more than 650 were spent their lives under primitive conditions. Only 70 of our fore-fathers had an effective means of communication with one another. Only the last 10 had really made use of the metal age. Only the last 4 had seen the locomotives and the last 2 electric motors. Vast [illegible] majority of items and materials that make up today's material wealth have been developed within our life time. Thus the growth of science and technology in the last few years has surpassed all the predictions of the science fiction writers and the gap between the discovery in science and its application to technology has reduced enormously.

Let us take a look at the progress made on the national scene during the last three decades. India, probably, has the third largest number of scientific personnel working in several research and development laboratories such as defence laboratories, CSIR laboratories, department of atomic energy, space department and over 100 universities and other technological institutions, most of which have been established during the last thrity years. In the recent past, a biginning has been made in establishing a link between these research institutions and industries which has helped to a considerable extent in promoting indigenisation and self reliance. The country has made considerable progress in all sectors of economy such as agricultural, industrial, health and so on. The progress made in the field of atomic energy has resulted in the establishment of atomic power stations. With the rapid strides made in space sciences and space technology in the last few years, India became the seventh space power, enabling us to utilise space technology for developmental purposes.

As a result of our scientific, technological and management policies, the Gross National Product of the country has increased from around Rs 9000 crores in 1950 to Rs 70000 crores in 1977 with a corresponding increase in the per capita income from Rs 250 to Rs 1100. Even at 1960-61 price index, we see that the industrial output of the country has increased three fold from Rs 1200 crores to Rs 3500 crores -- Agricultural output, almost two fold from Rs 5000 crores to Rs 9000 crores in value -- total energy consumption has increased ten rold to Rs 250 crores.

Substantial increases in the agricultural sector has resulted through the use of fertilisers and better seeds. Rice and wheat production, for example, which were 20 and 7 million tons respectively in 1950, now exceed 50 and 25 million tons, almost a three fold increase. The output of pulses, oil seeds and other agricultural products have also shown a substantial increase. The output of total food grains has increased from 50 to 120 million tons during the period 1950-1977. The area under total irrigation which was hardly around 2 million hectares in 1950 is now around 25 million hectares.

Improved technology and investments have had a significant impact in the mining and metal industry. The coal output, for example, which was just about 30 million tons in 1950 has now reached 75 million tons. Petroleum production which was under 0.5 million tons in 1950 now exceeds 8 million tons. The total value of mineral production output has increased seven fold and today it exceeds Rs 50,000 crores.

Traditionally, steel production and energy consumption are taken as two reliable indices of the level of industralisation. Iron and steel production, which was just about 1.5 million ton is now around 8 million tons. Production of aluminium has reached 180,000 tons, forty times more than what it was in 1950. Total energy production has increased ten fold to 70 billion KWH.

In the field of medicine and health care, the number of hospitals, dispensaries and registered medical practioners have increased almost by a factor of two to three. Consequently the average longevity has increased substantially from 28 years to 45 years and infantile mortality rate has been drastically reduced. The total export has also shown considerable increase from 600 crores rupees in 1950 to over 5000 crores rupees. The actual public expenditure in the planned outlay mode which was just around Rs 2000 crores in first plan period is now about Rs 40,000 crores in the fifth plan period. Considering that India, since independence had to fight two wars, has been subject to some catastrophic or other such as drought, floods, hurricane and earth-quake, almost every alternate year, the achievement is quite significant.

What is the real impact of these achievements in the context of the present world? The population of India which was just about 350 million in 1950 has now almost touched the mark of 600 million. Due to the inadequate family planning measures adopted and impractical policies often resorted to by those who are at the helm of affairs, the annual growth rate of population has not significantly decreased from 2% over the years. As a result, even though the overall GNP has increased by a factor of 6 over the last 15 years, per capita GNP has hardly gone up by a factor of 3 and is one of the lowest in the world. If inflation is considered, the per capita GNP of Rs 1100/- is only equivalent of Rs 400/- at the price level of 1960, thus clearly demonstrating that the quality of life has not significantly improved over the last thirty years. The present growth rate in GNP per year is less than 5% which can barely take care of the inflationary development.

Even though the output of food grains has increased substantially, the total yield per acreage is still far below what is elsewhere. With the increase in population, per capita food availability has only increased from about 400 gms to 450 gms which is insignificant. Thus, over

70% of our population are still under-nourished and about 20% are badly nouished. The per capita industrial production, likewise, has shown no significant change. For example, inspite of the appareently impressive looking growth, per capita annual consumption of aoil is still around 3 kg, sugar about 6 kg, cloth about 14 metres which is practically within 20% of what it was 25 years ago. The per capita energy consumption in India is still one of the lowest in the world being about 0.2 ton coal equivalent, about 50 times lower than in USA.

The above analysis shows that our achievements over the last three decades, even though impressive, have not been good enough to make a significant impact on our society. If so, what has gone wrong in our thinking and approach and who is to be blamed for the presently existing chaotic situation?

The most glaring failure in our planning has obviously been the failure in enforcing effective family planning programme. With the availability of limited resources, we cannot affort unchecked population growth. All the significant advances made so far have been essentially nulified by the population explosion, thus perpetuating poverty and misery. Even though the rate of expansion in industrial and agricultural sectors are comparable to that found elsewhere, the increase in population is responsible for the stagnancy in the per capita GNP. Effective measures, with appropriate incentives and vigorous implementation are absolutely necessary if the quality of life in India is to improve. The choice by the year 2000 will be clearly between 600-700 million well fed people or 1000 million people living practically under subhuman conditions if the present rate of expansion were to continue.

The second major problem that has hampered the rapid growth is the lack of an integrated science and technology policy. The total amount of expenditure on research and development, even though has increased over the years is still just about 0.5% of the national GNP, whereas it should be at least 1.5 to 2% of the national GNP, The greater problem is the lack of an integrated purposeful policy aimed at the overall development of the nation, in all spheres, without being bogged down by unrealistic, one track philosophical attitudes such as public sector vs private sector, large scale vs small scale industries, import vs indigenisation, rural vs urban development, high technology vs low technology etc. It is very important to realise that diversification and mix of all techniques are essential part of any development. Relevance, when interpreted in terms of technology has to broad enough to apply itself not only to the immediate practical problems but also to long term strategy. Appropriate technology does not mean a single option but a mix of various options in an appropriate manner to achieve the final objective. If sicne science and technology has permeated every aspect of public and private life, social attitudes and dogmas have traditionally been unable to keep pace with scientific rationality. Even though science and technology is universally encountered, it is almost universally not understood. Under these conditions, it is imperative that we allow professional scientists and technologists to plan the growth and development of a nation.

The low standard of morale in public life and at high places is one of the primary causes for frittering away our meagre resources instead of channelising these towards national development. A rational scientific policy, because of the long questation period involved in fructification of a programme requires long term planning and not be purely based on 5 year plans due to political expediency. On the side of scientists and technologists, poor management and tendency to align with immediate interests of political pundits instead of taking an objective long term view has been responsible for the misfortune, which we can ill afford. To quote Mr Krishna Menon "You scientists are the souls of the medival times and you are willing to oblige your political masters by justifying and rationalising their aims with all the knowledge you have, irrespective of its value".

Coming to the educational scene, I do not believe that anything is basically wrong with our educational system. It is true that up-dating curriculum, modernisation are necessary but these are not the basic evils of our education system. I believe the present generation is far better equipped than we were in meeting the demands of the future. The problem is because of people meddling in our educational system by all and sundry and in fact by those who know little about education. One of the important actions, in my opinion, is to provide continuing education periodically to up-date our teachers and our engineers. I believe that this is the only way to ensure that technological obsolescence does not overtake our technocrats and scientists. I, personally, believe that if this is not implemented, the developing countries are likely to go through a new type of colonialism--technical colonialism which is far more dangerous that the colonialism, we have known so far and which we do not know how to tackle.

Man is a technological animal. It is basically technology which sets limits to man's activity and to a large extent defines the state of his cultural and economic evolution. In other words, to quote Mr Ferkiss, "Technology is the independent variable, the social system the dependent variable". Whereas, in principle, one can hope science and technology, when purposefully utilised can find solutions, it is very important to recognise that it is no longer resources that limit decisions but decisions that make the resources. Whereas science and technology can only provide a powerful tool, the use of it towards betterment of manking requires collective political will and sound scientific management. For a developing country like ours the meaning of these words is very profound and if we fail to choose the right options, the consequences can be disastrous. It we do not wake up even at this late hour and try to remedy the situation, history will condemn us as future generations will have to go on emply stomachs.

I hope, I have raised some of the important questions and some more will be raised by my fellow panelists which can generate a healthy discussion amongst the panelists and audience resulting in a set of recommendations.

SESSION—10

NATIONAL SEMINAR
ON
EDUCATING THE ENGINEER OF THE FUTURE
BANGALORE, JANUARY 7-10, 1979

S-10

Keynote Address by Prof T Ramasarma

Keynote Address by Dr (Smt) S Balaraman

ADDRESS BY PROF T RAMASARMA

I work in the Indian Institute of Science where a group of scientists and engineers along with some others in this city and elsewhere in the country formed an association a few years ago called the Association for Application of Science to Human Affairs (ASHA). The acronym ASHA in Sanskrit means "hope". We are interested to study what is "development" - the one word appearing in the title of the talk. Dr Bhagavantam, President of the ASHA, asked a group of the members to define "development". This study led to formulation of what is called "ASHA Development Index".

If the great, great grandfathers had to have a meeting, they must find a large cave. If they wanted to go for lunch they should go out into the nature to collect food. Only 10,000 years ago, and this is not very long in the time scale of evolution of man and trivial in the evolution of earth, the agricultural development took place. The people at that time selected food-bearing plants from the nature and developed wheat, rice, etc. Today we have a number of them and none of them has been developed after our so called modern science and technology came into being.

200 years ago India was much more prosperous than the West. In fact, they looked to us and wanted to develop to that level as much as we are now looking to the West. The reason for this change is the industrial revolution. They could obtain more materials from nature and increase living comforts directly out of the efforts of science and technology. We tend to link development to the material comforts of life. If we are looking for that kind of development where we need large scale production of materials, consumer goods, cars, TV, etc, then we have to follow the path of industrialisation in the same manner as they did and try and reach their standard of living. Each country has this potential and it is only a question of time - 20, 30 or 100 years before this is achieved. However, before that happens something else happen - that is, increase in population.

Often we are asked to define development. Development speeds up the process and gives the people of each country their minimum needs, the basic needs which they should, as human beings, possess. We cannot live in the cave, we cannot go out in search of food every day, we cannot go out without clothes, we cannot go without a house, we cannot go without education and the benefits of knowledge acquired over the period of 200 years. If that is the kind of definition of development we accept, we can go on to see how it could be quantitated. The main departure in the approach is that poorer countries

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Prof T Ramasarma is with Indian Institute of Science, Bangalore cannot take the same path for development as the West did. Each country and each society has to define its own minimum requirements and the kind of life style they can have depending on the resources available. About 20 years ago, the U N started the "Development Decades" - the 1960s as the first decade and the 1970s as the second decade. And each decade has seen the aspirations grow and the result were distressingly low. We are no doubt developing as speakers pointed out. The GNP, which is the best indicator that we have now, has increased but the disparity between the developed and the developing countries is much greater than it was before we started the development decades. We have the resolution that by the end of second development decade the disparity in the GNP, should at least be minimised if not equalised. Equalisation is perhaps out of question. Sooner we realise this, the better for our development plans. Our GNP per capita is hardly $ 300 a year and the highest in Europe is over $ 10,000 dollars. It is doubtful if we will ever reach that level with the natural resources, the wealth and the population we have. There is little possibility that we will even reduce the gap, much less reaching even this standard. By the time our GNP increases a little, they move far higher. I think we should not compare and suffer. We should on the other hand attempt to reach our own defined development standards and not the pattern of the West.

The GNP gives the level of material prosperity based on industrialisation. This is limited in scope as an index. It is not considered a true index of development because we can have situation with high GNP but low quality of life and at the same time have a low level GNP but satisfactory living conditions with basic needs provided.

There is a group in the USA called Overseas Development Council,which gave another index, called Physical Quality of Life Indux (PQLI). This has omitted the GNP and adopted the quality of life as defined by three parameters: (i) infant mortality, (ii) life expectancy and (iii) literacy. These reflect health, nutrition and education of a community. PQLI takes numbers for these, sum them up and then get an index. They have taken the case of Sweden as 100 and normalized the rest of them in the scale of 0-100. Most developing countries fall much below 100. If we accept this kind of index, we may continue to suffer from comparison with those whose indix is 100. We may continue to have large disparity in the 0-100 scale. It might however be a better index than GNP because we are talking quality of life. But this is not sufficient as we have no parameter of development process or growth. Therefore, we considered that we should integrate the two benefits of GNP and PQLI and obtain a better index. One of the important parameters we introduced in the index is employment. The people, first of all, should have the

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potential to work and make a living. In most developing countries where poverty exists the major problem is that the people do not have the ability to work and make a living. We want employment, literacy, life expectancy and growth rate to be improved in a development process. A growth rate was envisaged at 10% in the development decades but hardly 3% was achieved by many developed countries. This reflecting productivity of a country will give a qualifying parameter for the index and is kept in the numerator. Then we have the birth rate and infant mortality as counterweighing factors which are kept in the denominator. The index goes up when numerator values go up or when the denominator values go down. A composite index is obtaine by the product of these quantities with employment, literacy, life expectancy and productivity in the numerator, and birth rate and infant mortality in the denominator as shown below and is given the name ASHA Development Index (ADI).

$$\text{ADI} = \frac{\text{growth rate x employment x literacy x life expectancy fracti}}{\text{birth rate x infant mortality}}$$

The least developed countries will have a number of 80 to 100 and the most developed will go beyond 10,000. If any one of these parameters improves the rest will improve, because each one has a telling effect on the others. Therefore, improvement in steps of each one of these parameters indicates an overall development. We hope this is a better index than the others. GNP gives only the economic or productivity index and PQLI for the well being index but ADI will be an index for development. This index will also tell us the way in which developmental efforts should be directed.

But for science and technology the West could not have developed and without these developing countries also would not develop. How to use these under the conditions obtained in a countr with a large, poor population which have no means of making a living. With the basic needs for all in view we have to plan inputs for maki all persons fit to earn and make a living. This should be the basic approach for any development. The engineer has his role as much as the scientist.

I has been mentioned by various speakers that production has to be increased to meet the material requirements and this has to be for the people and by the people. An example is about the advances being made in the engineering science about modifications of weather and its application. In our country, agricultural production depend on rains. If rains come at the appropriate time and in sufficient

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quantity we have good crops, and if it fails the crops fail. There seems to be a 4-year cycle in this. If definite technology could be developed to get the rains at the appropriate time then we would have achieved stability in agricultural production.

I always wondered what "engineering" meant. When we use the word "engineer" as a verb it means to make possible. I looked at etymology of the word and found that to engineer is "to beget by wit". In the present context, the engineer has to beget the developmental needs from the resources of the country by his "wit" or skill.

GOALS OF BASIC ENGINEERING EDUCATION

DR SHAKUNTALA BALARAM

Although many national seminars have been organized to discuss the design of post-graduate and undergraduate engineering education, there have hitherto been no systematic studies on what should be the goals of engineering education. I would like to present a brief account of a successful systematic attempt which was recently made to identify the goals of the basic undergraduate engineering programme.

In 1974, a Joint All-India Council of Technical Education - University Grants Commission (AICTE-UGC) Committee was set up to provide guidelines on how the first degree course in engineering was to be reformulated and improved, to meet the social, economic and technological changes of the immediate future. The focus was on the immediate future and not on the year 2001 AD. In 1976, the Joint Committee appointed various Study Groups to make intensive investigations on various facets of this problem. A Delphi study on the goals and priorities of basic engineering education was conducted by a faculty group in the Indian Institute of Technology, Madras on behalf of Study Group 1. This Delphi study is very relevant to today's discussion on "Educating the Engineers of the Future".

Since most of you are familiar with the Delphi technique, it is not necessary for me to review the technique or describe it. It has received wide usage in the U S A and has spread to Denmark, U K, U S S R, Canada, Japan, Australia and India. It is applicable to a wide variety of fields and in recent years, there have been attempts to apply it to the field of education and decision-making at different levels of education planning. Almost all Delphi applications in education are normative in character, that is, they focuss on what ought to be achieved rather than on what is likely to happen.

Our Delphi study was monitored by a committee of six faculty members: Prof K S Hegde (Director of M I T, Madras), Dr S Ramani (Professor of Industrial Engineering and Management, I I T, Madras), Dr V G K Murti (Professor of Electrical Engineering, I I T, Madras) Dr K S Venkatakrishnan (Lecturer in Mathematics, M I T, Madras), Shri K K menon (Lecturer in Industrial Engineering, I I T, Madras) and myself who co-ordinated the entire exercise from start to finish. Our objectives were: (1) To conduct a nation wide large-scale Delphi on the goals of engineering education for the coming decade (2) To reach a reasonable consensus on the priorities of the goals for the basic undergraduate engineering education programme and (3) To examine the utility of Delphi as a tool for increasing initial group consensus.

Madras

Dr Shakuntala Balaram is with IIT, Madras.

The Delphi panelists were drawn from a national sample and consisted of group of 100 to 124 engineers and technologists from industry, R and D organizations, engineering colleges and institutes. Invitations to participate in this exercise were sent to 278 potential participants and 150 acceptances were received. In the Industry Group we had Managing Directors and General Managers of private and public sector industries (such as steel, heavy electricals, electronics, machine tools, chemicals etc.). Seven panelists who were selected to represent engineers in the Services and Defence were included in this Group. In the Education Group, we had Directors of the Indian Institutes of Technology, Directors of Departments of Technical Education (State Government), Principals of Regional Engineering Colleges, Principals of government and private engineering colleges and a few senior university professors and Vice-Chancellors. In the R and D Group, we had Directors of CSIR Laboratories and other national research institutions, the Chairman of the Atomic Energy Commission and the heads of R and D departments in various public sector industries. I would like to mention that six persons who have played an important part in this Institution of Engineers Convention, also served as panelists in our Delphi viz: Lt Gen J S Bawa, Prof G R Damodaran, Dr V C Kulandasamy, Dr F C Kohli, Dr G S Marwaha and Prof B R Narayana Iyengar.

Four rounds were conducted by us and the participation rates were: 1st Round-106; 2nd Round-124; 3rd Round-100; 4th Round-109. The ratio of participation from industry, education and R and D for each round was 4:3:2, respectively. Forty goals of engineering education were formulated and they were placed in three major categories : (1) National tasks towards which engineers should contribute (2) Professional skills and (3) Professional attitudes which should be developed if engineers are to contribute to national tasks. Seventeen national tasks, 14 professional skills and 9 professional attitudes were identified. For each national task, the experts provided a list of primary activities for engineers in the coming decade. For example, for the goal area identified as Rural Development, they stressed activities such as agricultural mechanization, design and fabrication of agricultural implements, post-harvest technology, housing with local materials, efficient drainage and waste recycling.

We now come to priorities of these goals for basic engineering education. Although the panelists were given a choice of five scale values (High, Above Average, Average, Below Average and Low), it was found that most of them indicated priorities with three scale values: High, Above Average and Average. In the National Task category, four goal areas were given the highest priority and I list them in the order of priority in which they emerged: 1st - Energy Sources and Systems, 2nd - Food Production and Processing, 3rd - Industrial Development and 4th - Rural Development. Above Average priority was given to Housing, Water Management, Materials Science and Technology and Management Systems. Average priority was given to Health Care Scientific Research, Urban Development, Mass Communication, Transpo tation Systems, National Defence, Environmental Protection and Preservation, Educational Infrastructure, Clothing and Textiles.

In the Professional Skills category, the highest priori was given to Analytic Skills, Workshop and Fabrication Skills and Entrepreneur Skills. Above Average priority was given to Manageria Techniques, Communication Skills, Design Techniques, Experimental Skills and Project Planning. Average priority was given to Enginee ring Graphics, Measurement Techniques, Interpersonal Skills, Comput tional Skills, Computer Usage and Self Study Skills.

In the Professional Attitudes category, the experts gav the highest priority to Professional Integrity. Interest in Updati Professional Skills and Knowledge, Willingness to Work in a Team towards Common Objectives, A Sense of Professional Pride, - these attitutes also received the highest priority. Above Average priori was given to Quality Consciousness in Work and Appreciation of the Role of Skilled Manual Labour. Average priority was received by Aesthetics in Engineering Design, Sensitivity to Social Needs and Aspirations and Awareness of Social Consequences of Technological a Industrial Activity.

It should be mentioned that at the end of the fourth (final) Delphi round, the consensus had increased for every one of the 40 goals. We have reason to believe that this increase in cons sus was due to the Delphi procedures adopted by us.

Are these goals being achieved today? To find an ans to this question, we will first have to solve the problem of identi fying goals in an educational programme. It should be possible to assess goal attainment by analysing the nature and number of contac hours, faculty positions and student enrolments, course titles and content, project work, continuing education programmes, teaching methods and extracurricular activities.

If the goals of engineering education are to be linked to national development, engineering education institutes should be provided with periodic forecasts of engineering manpower requiremen (regional and national). A national manpower information system should be established for the storage, updating, retrieval and analysis of manpower information. Manpower projections should be based on dynamic models and sophisticated forecasting tools and techniques.

A limitation to the use of manpower prediction in India is that we lack inter-state mobility among engineering personnel owing to cultural differences (in language, food habits, community etc.) and the "Sons of the Soil" theory. This situation leads to imbalances of engineering manpower in the States, - in some States there are serious shortages of certain kinds of engineering personnel while in other States there is a surplus of engineers in this same speciality. To increase mobility and encourage national integration among engineers, it may be necessary to establish an Indian Engineering Personnel Service similar to the I A S. A strict manpower forecasting approach to educational planning has the disadvantage that it ignores the relation between the expected benefits of education (in the form of additions to national income produced by highly qualified manpower) and the costs of education and training. Cost-benefit considerations may suggest different policy conclusions from those of manpower forecasting.

The World Yearbook of Education (1967) identifies three approaches to changing educational systems: (i) The social demand approach (exemplified by the Robbins Report in the U K and the Goals Study in the U S A) (ii) The manpower forecasting approach, which attempts to identify the future manpower requirements of an economy and to develop the educational system in accordance with those needs and (iii) The cost-benefit approach (based on estimates of the economic returns to education). All three approaches have their strengths and weaknesses. The integration of these three approaches within a single framework will probably be ideal for educational planning in developing countries.

I can only highlight a few of the implications of the goal structure suggested by the experts. To keep pace with changing national goals, more flexibility should be introduced into the somewhat rigid basic engineering programme, by introducing new elective courses at every stage and for every branch of engineering (For example Rural housing, Solar energy utilization, Pollution control, Agricultural mechanization). Elective courses should be offered in the Humanities and Social Sciences, to meet the personal and social needs of students. Students should be encouraged to participate in community service projects and should receive course credits for these activities.

To help students achieve high levels of professional skills, the faculty should adopt effective teaching and communication methods. Since research has shown that engineering college faculty are not averse to the idea of attending short-tern coursesin teaching technology, two or three Teacher Training Centres may be established on a trial basis, in the Deemed Universities.

Since many professional attitudes have been given high priority by both experts and faculty, serious consideration should be given to techniques of attitude change. We must seek the advice of the bahavioural scientists for this. To reach the attitudinal goals, elective courses in Social Sciences, group projects and various extracurricular activities such as N S S work, debates, student seminars, talks by guest speakers, inplant training, outdoor camps and hikes etc could be planned. Increased interaction and fre exchange of ideas between faculty and students may go a long way in bringing about attitude changes in students.

To train engineers for national tasks and keep them informed of future professional ddvelopments, we may consider reorganizing our traditional engineering departmental system into ten or more departments, - for example, Structural Engineering, Production Engineering, Architecture and Planning, Hydraulic Engineering, Environmental Engineering, Electrical Power Engineering, Communication Engineering, Thermal Engineering, Chemical Engineering, Mineral Processing. It should be possible to classify all present engineering activity rationally under one or other of the above divisions. The fact that the majority of our engineering colleges organize their undergraduate educational programme in only three disciplines-civil, mechanical and electrical-has led to loss of clarity and precision in the objectives of engineering instruction. The more rational structural reorganization suggested by us, could serve the purpose of achieving current national goals more effectively than the traditional structure. For example, if Energy is a high priority national goal, considerable academic emphasis and resource allocation should be given to thermal and electrical power engineering. Similarly, if Food Production and Processing receive high priority, chemical (fertilizer) engineering and hydraulic (irrigation) engineering should be stressed.

To further test the validity and acceptance of these goals on a national scale, we have recommended that these goals be circulated to colleges, university departments, Directorates of Technical Education (in the States) and other agencies concerned with higher technical education, with the request that they be subjected to critic discussion and examination by the academic community at large. The results of such discussions may be conveyed to the Ministry of Educat which may then refine this list, if necessary, and recommend it to all training and employment institutions in the country. Educational institutions should have the freedom to state their own goals in consonance with the stated national goals. Setting up of new departme initiating of new post graduate courses and organization of research activity should be in conformity with the priorities of the national goal structure.

For purposes of resource allocation, it is necessary that engineering colleges and institutes clearly state their educational goals and priorities. Individual institutions may agree to work in a limited area of the given national goals. Budget allocations should be made accordingly, depending on the resources available, on the lin of a Planning Programming Budgeting System. To ensure a balanced development and an integrated approach, the tasks of planning and organizing engineering education should be brought under a single Technical Education Commission, somewhat similar to the University Grants Commission.

By listing 17 national tasks towards which our engineers should contribute, our Delphi experts have implied that there is a 'mission' for Indian engineers. Indian engineers must be prepared to link educational goals to national development for the progress and betterment of our society. At the same time, they should realize that the 'mission of engineering' cannot be fulfilled without the inculcation of certain skills and attitudes in our young engineers and technologists.

FINAL RECOMMENDATIONS

NATIONAL SEMINAR

ON

EDUCATING THE ENGINEER OF THE FUTURE

BANGALORE, JANUARY 7-10, 1979

FINAL RECOMMENDATIONS

BACKGROUND

The National Seminar on 'Educating the Engineer of the Future' organized by the Institution of Engineers (India) concurrently with the 59th Annual Convention at Bangalore during January 7-10, 1979, deliberated in depth through invited lectures, contributed papers, general lectures and panel discussion, the whole problem of technical education to meet the needs of our preferred future around 2000 AD. While it can easily be understood that the problem is gigantic in nature, attempts have been made to arrive at a configuration within which our future technical education is to be planned. Evidently, the problems of the present have also received attention to identify the specific deficiencies which should not be allowed to repeat in the future, when we are required to meet a vast changing panorama of the developmental scene.

GOALS OF TECHNICAL EDUCATION

The main aim of technological education is to meet the societal needs to give a better quality of life to all our country-men. This Seminar felt that the goal should be: generation of wealth with full employment and increasing the quality of life rather than merely the GNP.

PRESENT PROBLEMS

While considering present problems, it was felt that there was considerable mis-match between requirements of industry and other sectors of economy and the type of engineering and technical education being imparted in our educational institutions. There is also a lack of interaction between technical institutions and the regions which they can effectively serve. There is much to be desired in the policy-making, planning and decision-making systems. There is considerable dependence of the technical institutions on the Government for directives and financial inputs. The interaction between industries and technical institutions is not adequate. The system of admissions, ie, the policies adopted for admission and testing of students, has been such that a vast number of students from rural and non-urban areas are unable to get a chance for higher technical education. The present system is felt to be somewhat rigid and unable to allow innovation and prompt injection of futuristic concepts into the academic programme. They are unable to respond to the rapidly changing technical and sociological scenarios. The present unemployment has been partly due to the unemployability of the students and partly due to the non-availability of suitable jobs. The systems of evaluation which ought to have been an integral and indispensable part of engineering education have been faulty and do not serve as an index of the ability of the students.

EXTENSION SERVICES

Conscious of these present deficiencies, the Seminar discussed the futuristic needs and developed several useful suggestions for the consideration of the planners, academicians and users. One of the basic aims of any technical education is to serve the various sectors of economy and contribute to the physical quality of life of the people. As such technological extension services like the agricultural extension services have to form and integral part of any educational system. This implies that technical education and training at the technician level, which is at present discipline-oriented should be replaced by a system and product oriented education with alternate modules to enable the student to opt for choices based on his need which is obviously guided by the needs of the region in which he will use his technical capabilities (Fig 1).

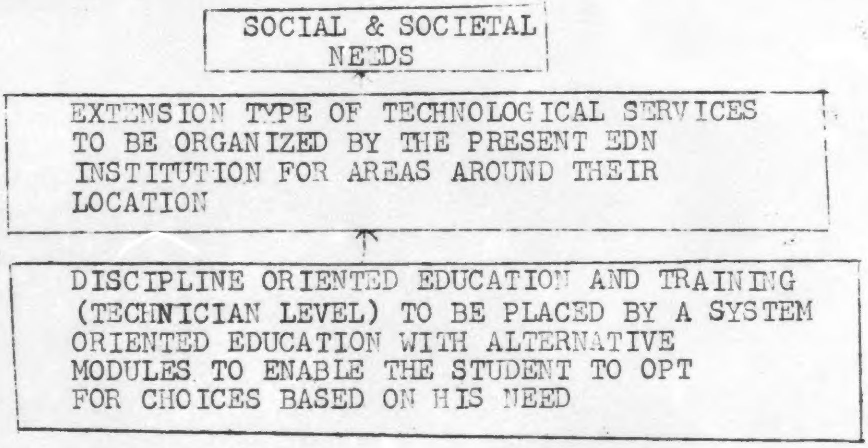

SOCIAL & SOCIETAL NEEDS
EXTENSION TYPE OF TECHNOLOGICAL SERVICES TO BE ORGANIZED BY THE PRESENT EDN INSTITUTION FOR AREAS AROUND THEIR LOCATION
DISCIPLINE ORIENTED EDUCATION AND TRAINING (TECHNICIAN LEVEL) TO BE PLACED BY A SYSTEM ORIENTED EDUCATION WITH ALTERNATIVE MODULES TO ENABLE THE STUDENT TO OPT FOR CHOICES BASED ON HIS NEED

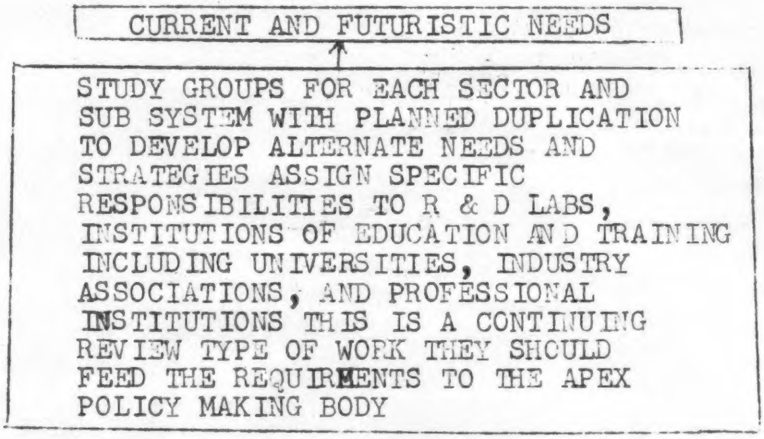
Fig 1 Technician level education and social needs

IDENTIFICATION OF FUTURE NEEDS

To identify the current and futuristic needs of these regions study groups for each sector of economy, and special systems with planned duplication to develop alternate needs and strategies, should be constituted. Specific responsibilities should be assigned to R & D agencies, institutions of education and training, like the universities, industrial associations and professional institutions. There should be a continuing review and assessment of the needs (Fig 2).

HIGHER TECHNICAL EDUCATION

Education at the higher level should be selective and essentially user sponsored, with direct entry being available. Higher education should address itself to meet the man-power needs of R & D terms, futuristic study groups, high technology application and maintenance systems. This area of education by necessity, therefore, will have to be formal which means institutionalization (Fig 3).



CURRENT AND FUTURISTIC NEEDS

STUDY GROUPS FOR EACH SECTOR AND SUB SYSTEM WITH PLANNED DUPLICATION TO DEVELOP ALTERNATE NEEDS AND STRATEGIES ASSIGN SPECIFIC RESPONSIBILITIES TO R & D LABS, INSTITUTIONS OF EDUCATION AND TRAINING INCLUDING UNIVERSITIES, INDUSTRY ASSOCIATIONS, AND PROFESSIONAL INSTITUTIONS THIS IS A CONTINUING REVIEW TYPE OF WORK THEY SHOULD FEED THE REQUIRMENTS TO THE APEX POLICY MAKING BODY

Fig 2 Current and futuristic needs

HIGHER EDUCATION NEEDED FOR MEETING MAN POWER REQUIREMENT FOR

- R & D TEAMS & FUTURISTIC STUDY GRPS
- ANALYTICAL STUDY GRPS
- APPLICATION WORK IN HIGH TECHNOLOGY AREAS
- MAINTENANCE OF HIGH TECHNOLOGY SYSTEM
- CAN ONLY BE INSTITUTIONALISED

(fig 3 contd)

- ENTRY INTO HIGHER LEARNING INSTITUTIONS FOR INDUSTRY SPONSORED CANDIDATES WITH AN UNDERSTANDING OF THE INDUSTRIAL SYSTEM TO BE PROVIDED FOR DIRECT ENTRY ALSO TO BE AVAILABLE

Fig 3 Higher education

NON-FORMAL SYSTEM : NEED AND METHODOLOGY

In view of the goal of achieving full employment and also the large numbers of technical personnel that will be required, the resources needed to give formal education are going to be enormous in terms of resource needs. So it will become essential to develop non-formal systems of education for which all available mass media should be harnessed. At the present time, the audio component can be met by the radio while the visual aid can be met by newspapers and periodicals. It is suggested that the advertisement budget of the industry may be utilized by them to highlight futuristic technologies and their applications. Movies can be very effectively utilized for the purpose of technical education. All this is expected ultimately to lead to a vast TV educational network (Fig 4).

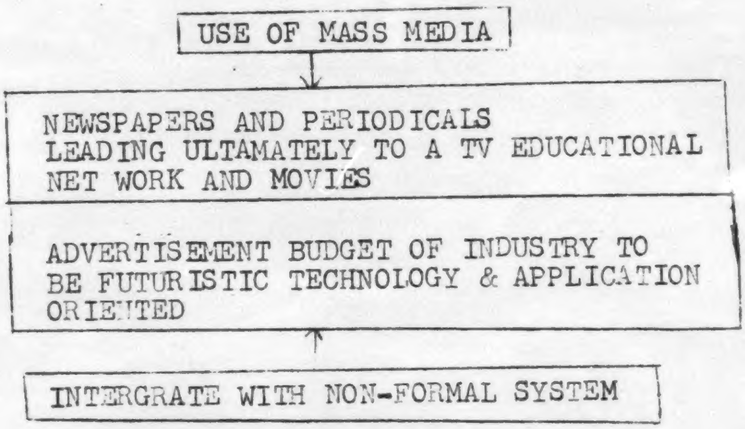

USE OF MASS MEDIA
NEWSPAPERS AND PERIODICALS LEADING ULTAMATELY TO A TV EDUCATIONAL NET WORK AND MOVIES
ADVERTISEMENT BUDGET OF INDUSTRY TO BE FUTURISTIC TECHNOLOGY & APPLICATION ORIENTED
INTERGRATE WITH NON-FORMAL SYSTEM

Fig 4 Non-formal system and mass media

CONTINUING EDUCATION

At present, the continuing education programmes are reasonably well developed at all levels as far as educational institutions are concerned. However, they require great attention at the user end for in-house continuing education programmes (Fig 5).

CONTINUING EDUCATION

- REASONABLY WELL ORGANIZED AT ALL LEVELS AS FAR AS THE EDUCATIONAL INSTITUTIONS ARE CONCERNED
- REQUIRES ORGANIZATION AT THE USER END FOR IN HOUSE CONTINUING EDUCATION

Fig 5 Continuing education

ACADEMIC PROGRAMMES : MANAGEMENT EDUCATION

The basic approach in any academic programme should be to develop in the student the capability to identify and define system needs, capability for real life problem solving, capability for organization and management leadership, and to use the disciplines in which they are trained as tools to perform these functions. He must be prepared to think and have the capability for continuous self-education and self-evaluation in relation to social and organizational needs.

As the engineer grows in his profession, he is required to take on more and more management responsibilities. As such, management education should form a basic integral component of higher technical education. Humanities content must be retained to give him a better appreciation of management concepts and human aspirations. It should be emphasized that technology without humanism or science without spirituality are of non value ultimately. For a successful model to transfer technology effectively, a basic understanding of and competence in the technology and its application is a requirement for good managers.

FACULTY

On the side of faculty, it must be recognized that the society and its pressures and needs are going to be felt by the teachers in a much greater measure in the future. The faculty, therefore, has to acquire an appreciation of the social and environmental needs, must imbibe system design concepts and interest themselves in effective communication systems. They should not be afraid of self-evaluation and evaluation by students. They should get involved more and more in extension type of work and must understand organizational and management concepts for their own good if not to meet the social needs. Otherwise they will be alienated from their surroundings and will become obsolete too soon (Fig 6).

EVALUATION SYSTEMS

The evaluation systems needs considerable attention in the future when non-formal education becomes an important component of our educational system. It is suggested that an independent GRE type system be developed in addition to the present formal system. This will give opportunity to the student to display his aptitudes, understanding knowledge and creativity. We must encourage independent evaluation by users. Professional bodies have to play an important role in the recognition mechanisms for the non-formal educational systems (Fig 7)

FACULTY DEVELOPMENT

EXPOSURE TO-SOCIAL AND ENVIRONMENTAL NEEDS
- SYSTEM DESIGN AND DETAILS
- EFFECTIVE COMMUNICATION SYSTEMS AND TOOLS
- EFFECTIVE STUDENT AND SELF-EVALUATION SYSTEM
- EXTN. TYPE OF EXPERIMENTAL DESIGN
- ORGANIZATIONAL AND MANAGEMENT CONCEPTS AND METHODS

TO BE ACHIEVED BY A FORMAL -INFORMAL SYSTEM

Fig 6 Faculty development

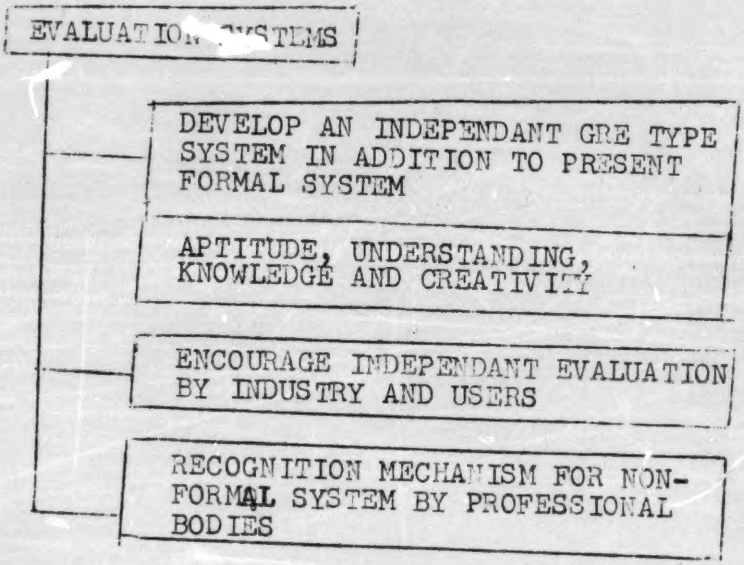

EVALUATION SYSTEMS
DEVELOP AN INDEPENDANT GRE TYPE SYSTEM IN ADDITION TO PRESENT FORMAL SYSTEM
APTITUDE, UNDERSTANDING, KNOWLEDGE AND CREATIVITY
ENCOURAGE INDEPENDANT EVALUATION BY INDUSTRY AND USERS
RECOGNITION MECHANISM FOR NON-FORMAL SYSTEM BY PROFESSIONAL BODIES

Fig 7 Evaluation systems

POLICY AND DECISION-MAKING

On the policy-making and decision-making side an important principle that is recommended is that the apex bodies like UGC and AICTE should limit themselves to policy making. They should get inputs for decision making from centres of policy studies, centres for evaluation studies and centres for input studies. These centres must be organized in universities, industrial associations, professional bodies and independent agencies. In-depth studies must be made on several areas and this should be available for the apex body for their decision making to emphasize action. The apex body should never get involved in the implementation of these policies. The above centres will serve as agencies for review monitoring, innovation, feedback studies and develop alternative models for growth and development (Fig 8).

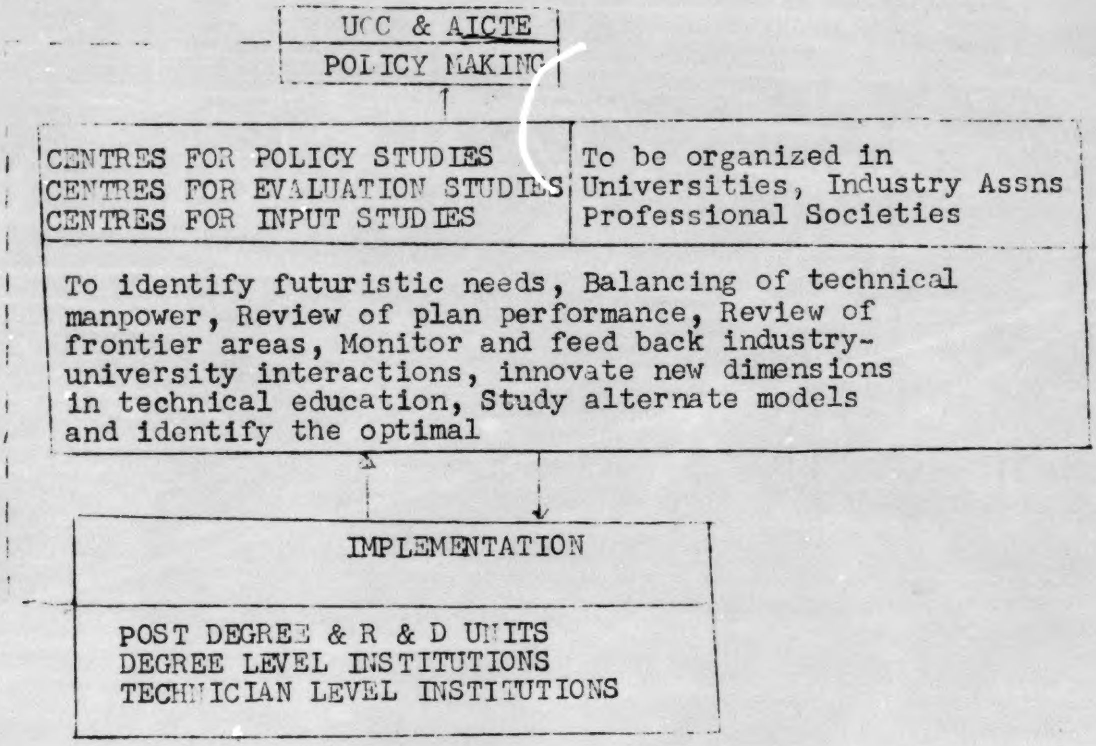

UGC & AICTE
POLICY MAKING
CENTRES FOR POLICY STUDIES
CENTRES FOR EVALUATION STUDIES
CENTRES FOR INPUT STUDIES
To be organized in Universities, Industry Assns Professional Societies
To identify futuristic needs, Balancing of technical manpower, Review of plan performance, Review of frontier areas, Monitor and feed back industry-university interactions, innovate new dimensions in technical education, Study alternate models and identify the optimal
IMPLEMENTATION
POST DEGREE & R & D UNITS
DEGREE LEVEL INSTITUTIONS
TECHNICIAN LEVEL INSTITUTIONS

Fig 8 Policy, decision-making and implementation

It is suggested that all policy and decision-making bodies should be small and compact consisting of between 5 to 20 members. If for some reason a body exceeds the number 20, standing committees must be constituted. Discussion forums should be large and should be built up in a hierarchy of groups of 50. No study group should have more than 10 members but generally it must have 5 only (Fig 9).

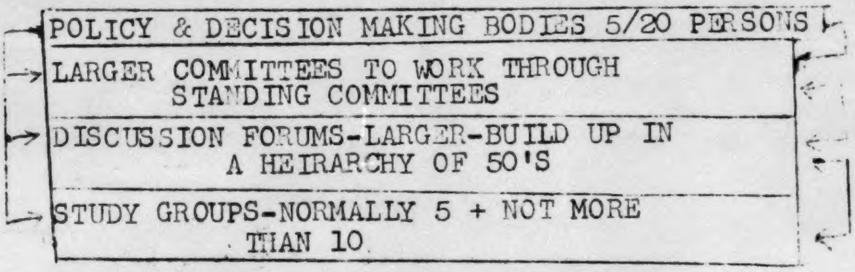

POLICY & DECISION MAKING BODIES 5/20 PERSONS
LARGER COMMITTEES TO WORK THROUGH STANDING COMMITTEES
DISCUSSION FORUMS-LARGER-BUILD UP IN A HEIRARCHY OF 50'S
STUDY GROUPS-NORMALLY 5 + NOT MORE THAN 10

Fig 9 Critical sizes for functional bodies

IMPLEMENTATION OF DECISIONS

At the implementation level the technical institutions should be involved. The higher technological institutions, R & D units, degree level institutions, technician level institutions, non-formal education groups should be allowed to operate independently so that they can use as effectively as possible their innovative and administrative abilities (Fig 8).

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